KEITHLEY

Model 6517 Electrometer

Calibration Manual

Contains Performance Verification and Calibration Information

KEITHLEY

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Calibration Manual

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture rear panel, or switching card.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC main. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a screw is present, connect it to safety earth ground using #18 AWG or larger wire.

The symbol on an instrument or accessory indicates that 1000V or more may be present on the terminals. Refer to the product manual for detailed operating information.

Instrumentation and accessories should not be connected to humans.

Maintenance should be performed by qualified service personnel. Before performing any maintenance, disconnect the line cord and all test cables.

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1

Performance Verification

1.1 Introduction

The procedures in this section are intended to verify that Model 6517 accuracy is within the limits stated in the instrument one-year accuracy specifications. These procedures can be performed when the instrument is first received to ensure that no damage has occurred during shipment. Verification may also be performed whenever there is a question of instrument accuracy, or following calibration, if desired.

WARNING

The information in this section is intended for use only by qualified service personnel. Do not attempt these procedures unless you are qualified to do so.

NOTE

If the instrument is still under warranty, and its performance is outside specified limits, contact your Keithley representative or the factory to determine the correct course of action.

This section includes the following:

1.2 **Environmental conditions:** Covers the temperature and humidity limits for verification.

1.3 **Warm-up period:** Describes the length of time the Model 6517 should be allowed to warm up before testing.

1.4 **Line power:** Covers power line voltage ranges during testing.

1.5 **Recommended equipment:** Summarizes recommended test equipment and pertinent specifications.

1.6 **Verification limits:** Explains how reading limits were calculated.

1.7 **Restoring factory default conditions:** Gives step-by-step procedures for restoring default conditions before each test procedure.

1.8 **Voltage offset and bias current calibration:** Covers methods to null voltage offset and bias current.

1.9 **Meter verification:** Details procedures to verify accuracy of Model 6517 measurement functions: volts, amps, coulombs, and ohms.

1.10 **Voltage source verification:** Covers verifying voltage source output accuracy.

1.11 **Temperature verification:** Explains how to check temperature measurement accuracy.

1.12 **Humidity verification:** Summarizes the basic procedure to check humidity measurement accuracy.

1.2 Environmental conditions

Verification measurements should be made at an ambient temperature of 18° –28°C (65° –82°F), and at a relative humidity of less than 70% unless otherwise noted.

1.3 Warm-up period

The Model 6517 must be allowed to warm up for at least one hour before performing the verification procedures. If the instrument has been subjected to temperature extremes (outside the range stated in paragraph 1.2), allow additional time for internal temperatures to stabilize. Typically, it takes one additional hour to stabilize a unit that has been in an environment 10°C (18°F) outside the specified temperature range.

The test equipment should also be allowed to warm up for the minimum period specified by the manufacturer.

1.4 Line power

The Model 6517 should be tested while operating from a line voltage within the range determined by the rear panel LINE VOLTAGE switch setting, at a frequency of 50 or 60Hz.

1.5 Recommended test equipment

The following paragraphs list test equipment recommended for performing the verification procedures for the various Model 6517 functions. Alternate equipment may be used as long as that equipment has specifications at least as good as those listed in the table.

1.5.1 Meter performance verification equipment

Table 1-1 lists all test equipment required for verifying the measurement accuracy of Model 6517 meter functions. This equipment will allow you to check the accuracy of the instrument volts, amps, coulombs, and ohms functions.

NOTE

The Model 5156 Electrometer Calibration Standard is recommended for verifying accuracy of the 20pA-2μA amps ranges, the 2GΩ-200GΩ resistance ranges, and all coulombs ranges. Alternate resistance and capacitance standards may be substituted as long as those standards are characterized to an uncertainty at least four times better than equivalent Model 6517 specifications.

Table 1-1
Recommended test equipment for meter performance verification

Mfg.	Model	Description	Specifications
Fluke	5700A	Calibrator	±5ppm basic uncertainty.[1] DC Voltage: 1.9V: ±7ppm 19V: ±5ppm 190V:±7ppm DC current: 19µA: ±576ppm 190µA: ±103ppm 1.9mA: ±55ppm 19mA: ±55ppm Ohms: 1.9MΩ (nominal) 19MΩ (nominal) 100MΩ (nominal)
Keithley	5156	Electrometer Calibration Standard	100MΩ[2] [2µA, 200nA] 1GΩ [2nA, 20nA, 2GΩ] 10GΩ [200pA, 20GΩ] 100GΩ [20pA, 200GΩ] 1nF [2nC, 20nC] 100nF [200nC, 2µC]
		Characterized resistors	1TΩ[3] 10TΩ 100TΩ
Keithley	4801	Low-noise coax cable	
Keithley	7078-TRX-BNC	Triax-to BNC adapter BNC to dual banana plug adapter	
Keithley	237-ALG-2	Triax to alligator clip cable*	
Keithley	CAP-31	Triax shielding cap	

1. 90-day calibrator specifications shown include total absolute uncertainty at specified output.
2. Equivalent resistance and capacitance standards may be substituted if characterized to four times better uncertainty than equivalent Model 6517 specifications.
3. Resistors must be characterized to four times better uncertainty than equivalent Model 6517 specifications.

*Short red and black clips to make triax short.

1.5.2 Voltage source verification equipment

Table 1-2 summarizes equipment recommended to perform voltage source verification.

Table 1-2
Recommended test equipment for voltage source verification

Mfg.	Model	Description	Specifications*
Keithley	2001	Multimeter	200V range: ±41ppm 1000V range: ±47ppm
Keithley	8607	Dual banana plug cable	

*1-year multimeter specifications are for full-range input.

1.5.3 Temperature verification equipment

Table 1-3 lists temperature verification equipment.

Table 1-3
Temperature verification equipment

Mfg.	Model	Description	Specifications
Omega	CL-307K	Type K Thermocouple Calibrator/Simulator	-190°C to +1300°C, ±0.4%

1.5.4 Humidity verification equipment

Table 1-4 summarizes test equipment recommended to verify the accuracy of the Model 6517 humidity measurement function.

Table 1-4
Humidity verification equipment

Mfg.	Model	Description	Specifications*
Fluke	5700A	DC voltage calibrator	0V, 0.5V, 1V, ±5ppm basic accuracy
		Banana plugs to clip leads	
		2, 1" lengths of solid #20AWG wire	

* DC voltage calibrator with better than 0.25% basic accuracy may be substituted.

1.6 Verification limits

The verification limits stated in this section have been calculated using only Model 6517 one-year accuracy specifications, and they do not include test equipment uncertainty. In cases where the Model 6517 apparently does not meet its published specifications based on stated reading limits, reading limits should be recalculated using both Model 6517 accuracy specifications and the total absolute uncertainty of the verification equipment.

Reading limit calculation example

As an example of how reading limits can be calculated using test equipment uncertainty, assume that the 200µA range is being tested using a 190µA input value, and the various specifications are as follows:

- Model 6517 200µA range one-year accuracy: ±(0.1% of reading + 5 counts)
- Calibrator total absolute uncertainty at 190µA output: ±103ppm

The calculated limits are:

Reading limits = 190µA ± [(190µA × 0.1% + 0.005µA) + (190µA × 103ppm)]
Reading limits = 190µA ± 0.21457µA
Reading limits = 189.7854µA to 190.2146µA

1.7 Restoring default conditions

Before performing **each** performance verification procedure, restore instrument bench default conditions as follows:

1. From the normal display mode, press the MENU key. The instrument will display the following:
   MAIN MENU
   SAVESETUP COMMUNICATION CAL
2. Select SAVESETUP, and press ENTER. The following will be displayed:
   SETUP MENU
   SAVE RESTORE POWERON RESET
3. Select RESET, and press ENTER. The display will then appear as follows:
   RESET ORIGINAL DFLTS
   BENCH GPIB
4. Select BENCH, then press ENTER. The following will be displayed:
   RESETTING INSTRUMENT
   ENTER to confirm; EXIT to abort
5. Press ENTER again to confirm instrument reset. The instrument will return to normal display with bench defaults restored.

1.8 Offset voltage and bias current calibration

Before performing meter verification procedures (checking accuracy of the volts, amps, coulombs, and ohms measurement functions), the offset voltage and bias current calibration procedure should be performed, as described in the following paragraphs.

1.8.1 Front panel offset calibration

To calibrate voltage offset and input bias current from the front panel, proceed as follows:

1. Turn on the Model 6517, and allow a one-hour warm-up period before calibrating offsets.
2. From normal display, press the MENU key.
3. Select CAL, then press ENTER.
4. Choose OFFSET-ADJ, then press ENTER. The instrument will prompt you as follows:
   CONNECT TRIAX SHORT
   Press ENTER to continue.
5. Connect the shorted triax cable (short red and black clips) to the rear panel INPUT connector, then press ENTER. The instrument will then perform voltage offset calibration, during which it will display the following message:
   Performing V offset calibration
6. The Model 6517 will then prompt you as follows:
   CONNECT TRIAX CAP
   Press ENTER to continue
7. Removing the triax short, and connect the triax shielding (non-shorting) cap in its place.
8. Press ENTER. The Model 6517 will perform offset current verification, during which it will display the following message:
   Performing I offset calibration
9. Press EXIT as necessary to return to normal display once both offset calibration procedures are completed.

1.8.2 IEEE-488 bus offset calibration

To calibrate voltage offset and input bias current using IEEE-488 bus commands, proceed as follows:

1. Turn on the Model 6517, and allow a one-hour warm-up period before calibrating voltage and current offsets.
2. Connect the triax shorting cable to the rear panel INPUT connector, then send the following command over the IEEE-488 bus:
   :CAL:UNPR:VOFF
   Wait until the instrument completes this step before continuing.
3. Removing the triax shorting cable, and connect the triax shielding (non-shorting) cap in its place.
4. Send the following command to the instrument over the IEEE-488 bus:
   :CAL:UNPR:IOFF
5. Wait until the instrument completes bias current calibration, then remove the cap from the rear panel INPUT connector.

1.9 Meter verification procedures

The following paragraphs contain procedures for verifying instrument one-year accuracy specifications for the following functions:

- DC volts
- DC amps
- Coulombs
- Ohms

NOTE

Ohms accuracy specifications are derived from both amps and voltage source specifications. Thus, it is not necessary to separately verify the accuracy of the ohms function. As long as the amps function and voltage source meet their respective accuracy specifications, ohms function accuracy is assured.

If the Model 6517 meter functions are out of specifications and not under warranty, refer to the calibration procedures in Section 2.

WARNING

The maximum INPUT level (HI to LO) is 250V peak. The maximum common-mode voltage is 500V peak.

Exceeding these values may cause damage to the unit.

Some of the procedures in this section may expose you to hazardous voltages. Use standard safety precautions when such hazardous voltages are encountered to avoid personal injury caused by electric shock.

NOTE

Do not connect test equipment to the Model 6517 through a scanner or other switching equipment.

1.9.1 DC volts verification

DC voltage accuracy is verified by applying accurate DC voltages from a DC voltage calibrator to the Model 6517 INPUT jack and verifying that the displayed readings fall within specified ranges.

Follow the steps below to verify DCV measurement accuracy.

1. Connect the Model 6517 to the calibrator, as shown in Figure 1-1. Be sure to connect calibrator HI to Model 6517 INPUT HI and calibrator LO to the Model 6517 INPUT LO using the low-noise coax cable, BNC-to-dual banana plug adapter, and the triax-to-BNC adapter as shown.
2. Turn on the Model 6517 and the calibrator, and allow a one-hour warm-up period before making measurements.
3. Restore Model 6517 factory default conditions, as explained in paragraph 1.7.
4. Select the Model 6517 2V DC range, and make sure the filter is enabled.

NOTE

Do not use auto-ranging for any of the verification tests because auto-range hysteresis may cause the Model 6517 to be on an incorrect range.

5. With zero check enabled, press REL to zero correct the instrument.
6. Set the calibrator output to 0.00000VDC, and disable zero check. Allow the reading to settle completely before continuing.
7. Enable the Model 6517 REL mode. Leave REL enabled for the remainder of the DC volts verification tests.
8. Set the calibrator output to +1.90000VDC, and allow the reading to settle.
9. Verify that the Model 6517 reading is within the limits summarized in Table 1-5.
10. Repeat steps 8 and 9 for the 20V and 200V ranges using the test voltages listed in Table 1-5.
11. Repeat the procedure for each of the ranges with negative voltages of the same magnitude as those listed in Table 1-5.

Table 1-5
Limits for DC volts verification

6517 DCV range	Applied DC voltage	Reading limits (18° to 28°C, 1 year)
2V	1.90000V	1.89949V to 1.900515V
20V	19.0000V	18.9950V to 19.0050V
200V	190.000V	189.883V to 190.117V

NOTES:
1. Repeat procedure for negative voltages of same magnitude.
2. Reading limits shown are calculated only from Model 6517 one-year accuracy specifications and do not include test equipment uncertainty.

1.9.2 DC amps verification

DC amps accuracy is checked by applying accurate DC currents to the instrument INPUT jack and then verifying that the current readings fall within appropriate limits. Note that two separate current verification procedures are provided because of the different equipment required. Basically, the amps verification procedures are divided into the following two groups:

- 20pA – 2μA range verification using a DC voltage calibrator and the Keithley Model 5156 Electrometer Calibration Sandard, which contains standard resistors.
- 20μA – 20mA range verification using a DC current calibrator.

20pA–2μA range verification

Accuracy of the 20pA-2μA ranges is verified by applying accurate currents derived from DC voltages and resistance standards, and then checking the displayed readings against calculated limits. Note that it is necessary to calculate reading limits for each range separately from the exact values of the resistance standards supplied with those standards.

Follow the steps below to verify measurement accuracy of the 20pA to 2μA ranges.

1. Connect the Model 6517 to the DC voltage calibrator and the calibration standards box, as shown in Figure 1-2. Initially, make connections to the calibration standard using the 100GΩ resistor.

NOTE

It is not necessary to connect the calibration standard to the Model 6517 DIGITAL I/O port when performing the verification procedures.

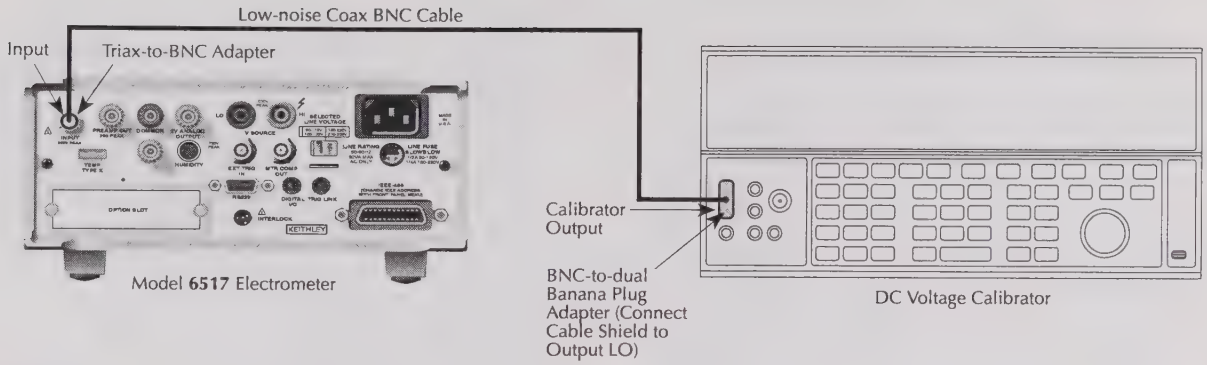

Figure 1-1
Connections for DC volts verification

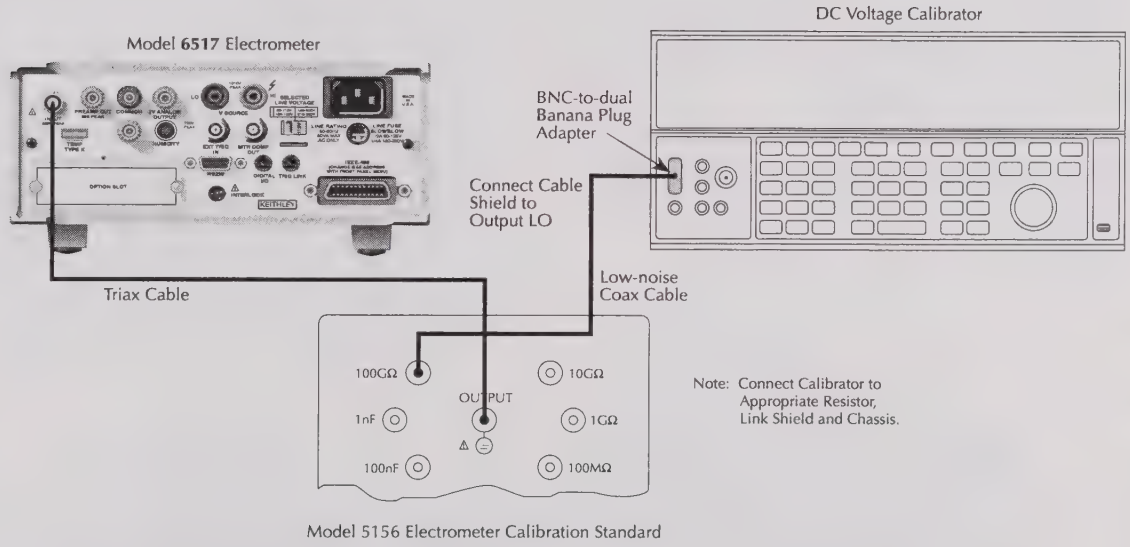

Figure 1-2
Connections for 20pA–2μA range verification

2. Turn on the Model 6517 and the DC calibrator, and allow a one-hour warm-up period before making measurements.
3. Restore Model 6517 factory default conditions, as explained in paragraph 1.7.
4. Select the amps function and the 20pA range on the Model 6517.
5. With zero check enabled, press REL to zero correct the instrument.
6. Set the calibrator output to 0.0000V, then disable zero check. Enable the REL mode to null offsets.
7. Record the actual resistance values (see Model 5156 calibration data) in the appropriate column of Table 1-6.
8. Calculate the actual calibration voltage from the desired current and the actual value of the 100GΩ resistor as determined from the calibration data as follows:

$$V = IR$$

Where: I = desired current applied to Model 6517
V = actual voltage from DC voltage calibrator
R = actual value of calibration standard resistance

After calculating the actual voltage values, record them where indicated in Table 1-6.

9. Set the DC calibrator to the actual voltage.
10. Make sure the DC voltage calibrator is in operate.
11. Allow the reading to settle completely, then note the reading on the Model 6517 display. Verify that the reading is within the limits listed in Table 1-6.
12. Reverse the calibrator voltage polarity, then make sure the magnitude of current reading is within limits.
13. Repeat steps 4 through 12 for the 200pA through 2μA ranges using the appropriate DC voltage and standard resistor listed in Table 1-6. For each range, be sure to:
    - Compute the actual calibrator voltage.
    - Set the DC voltage calibrator to the correct setting.
    - Null offsets using REL.
    - Make connections to the appropriate standard resistance in the calibration standard test box.

20μA – 20mA range verification

Measurement accuracy of the 20μA-20mA ranges is verified by applying accurate currents from a DC current calibrator and then verifying that the Model 6517 reading is within specified limits.

Proceed as follows:

1. Connect the Model 6517 to the DC current calibrator using the low-noise coax cable, triax-to-BNC adapter, and BNC-to-dual banana plug adapter, as shown in Figure 1-3. Be sure to connect the calibrator output HI terminal to Model 6517 INPUT HI, and connect calibrator output LO to Model 6517 INPUT LO.
2. Turn on the Model 6517 and the calibrator, and allow a one-hour warm-up period before making measurements.
3. Restore Model 6517 factory default conditions, as explained in paragraph 1.7.
4. Select the amps function and the 20μA range on the Model 6517.
5. With zero check enabled, press REL to zero correct the instrument.
6. Set the calibrator output to 0.000μA then disable zero check. Enable REL to null offsets.
7. Set the calibrator output to +19.0000μADC, and disable Model 6517 zero check.
8. Allow the reading to settle, then verify that the Model 6517 reading is within the limits for the selected measurement range, as summarized in Table 1-7.
9. Repeat steps 5 through 8 for the remaining ranges and currents listed in Table 1-7.
10. Repeat the procedure for each of the ranges with negative currents of the same magnitude as those listed in Table 1-7.

Table 1-6
Reading limits for verification of 20pA-2μA ranges

6517 range	Nominal voltage value	Standard resistor value	Applied current	Actual voltage*	Reading limits (1 year, 18° to 28°C)
20pA	1.9000V	100GΩ	19pA	_____ V	18.8070 to 19.1930pA
200pA	1.9000V	10GΩ	190pA	_____ V	188.095 to 191.905pA
2nA	1.9000V	1GΩ	1.9nA	_____ V	1.89590 to 1.91410nA
20nA	1.9000V	100MΩ	19nA	_____ V	18.9615 to 19.0385nA
200nA	19.0000V	100MΩ	190nA	_____ V	189.615 to 190.385nA
2μA	190.000V	100MΩ	1.9μA	_____ V	1.89800 to 1.90200μA

*Voltage calculated as follows: V = IR, where V is calibrator voltage, R is actual value of resistance standard, and I is desired applied current.

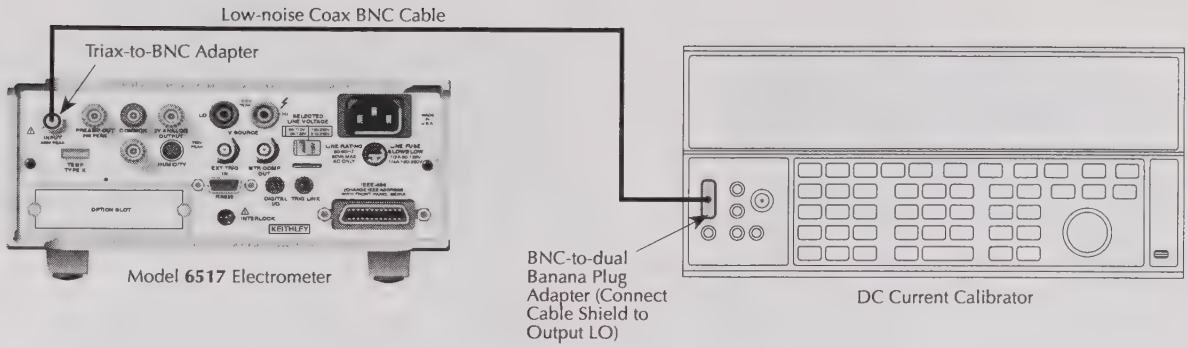
Low-noise Coax BNC Cable
Triax-to-BNC Adapter
Model 6517 Electrometer
BNC-to-dual Banana Plug Adapter (Connect Cable Shield to Output LO)
DC Current Calibrator

Figure 1-3
Connections for 20μA–20mA range verification

Table 1-7
Limits for 20μA–20mA range verification

6517 range	Applied DC current	Reading limits (1 year, 18° to 28°C)
20μA	19.0000μA	18.9805μA to 19.0195μA
200μA	190.000μA	189.805μA to 190.195μA
2mA	1.90000mA	1.89800mA to 1.90200mA
20mA	19.0000mA	18.9805mA to 19.0195mA

NOTES:
1. Repeat procedure for negative currents.
2. Reading limits shown calculated only from Model 6517 one-year accuracy specifications and do not include test equipment uncertainty.

1.9.3 Coulombs verification

Coulombs verification is performed by applying accurately known charge values derived from a voltage source and a capacitor to the Model 6517 INPUT jack, and then verifying that Model 6517 readings fall within specified limits.

Follow the steps below to verify coulombs measurement accuracy.

1. Connect the Model 6517 to the calibration standard then to the voltage calibrator, as shown in Figure 1-4. Initially, make the connections to the 1nF capacitor.
2. Turn on the Model 6517 and the DC voltage calibrator, and allow a one-hour warm-up period before making measurements.
3. Restore Model 6517 factory default conditions, as explained in paragraph 1.7. Also make sure that the offset-nulling procedure discussed in paragraph 1.8 has been performed.
4. Select the coulombs function and the 2nC range on the Model 6517.
5. Compute the desired calibrator voltages as follows:

$$V = \frac{Q}{C}$$

Where: V = calibrator voltage in volts
Q = charge in coulombs
C = standard capacitance value in farads

After calculating the voltage values, enter them where indicated in Table 1-8.

6. With zero check enabled, press REL to zero correct the instrument.
7. Disable zero check, and set the voltage calibrator output to 0.0000V.
8. Set the calibrator output to the calculated voltage. Allow the reading to settle completely.
9. Compare the Model 6517 displayed reading with the limits shown in Table 1-8.
10. Set the calibrator output to 0.000000V, and enable zero check.
11. Repeat steps 5 through 10 for the remaining ranges listed in Table 1-8. For each range, be sure to:
    - Set the Model 6517 to the appropriate range.
    - Make connections to the correct capacitor in the calibration standard.
    - Set the calibrator to 0V with zero check disabled.
    - Set the voltage calibrator to the calculated voltage value.
    - Compare the Model 6517 reading with the stated reading limits.

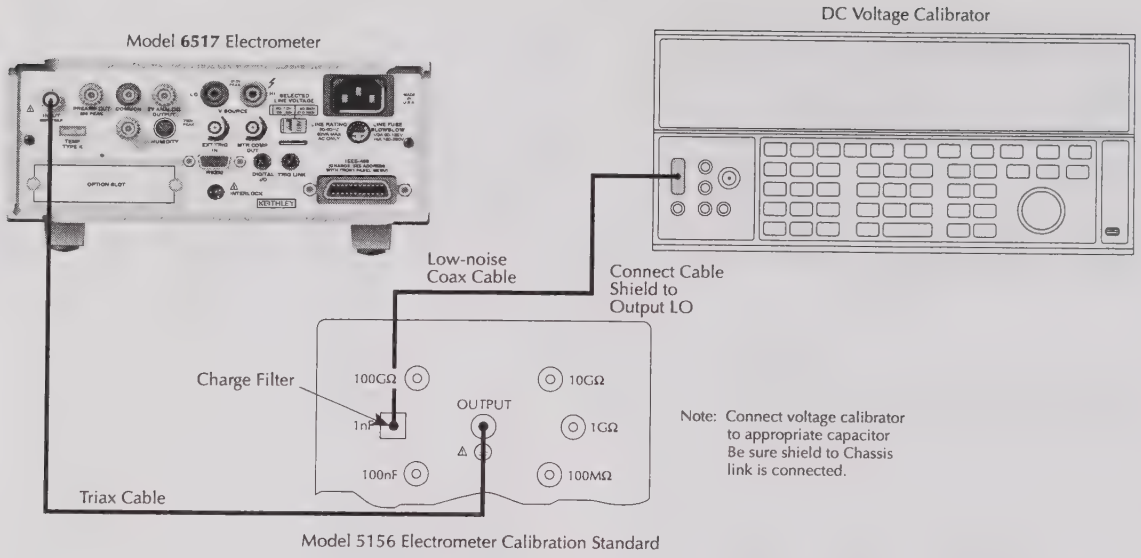

Figure 1-4
Connections for coulombs verification

Table 1-8
Limits for coulombs verification

6517 range	Standard capacitor[1]	Nominal voltage value[2]	Charge	Actual voltage[3]	Reading limits (1 year, 18° to 28°C)
2nC	1nF	1.90000V	1.9nC	_____ V	1.89235 to 1.90765nC
20nC	1nF	19.0000V	19nC	_____ V	18.9235 to 19.0765nC
200nC	1nF	190.000V	190nC	_____ V	189.235 to 190.765nC
2µC	100nF	19.0000V	1.9µC	_____ V	1.89235 to 1.90765µC

[1]Nominal value of capacitor in calibration unit.
[2]DC voltage applied by calibrator (nominal value)
[3]Actual voltage: V=Q/C.

1.9.4 Ohms verification

Ohms function accuracy is verified by connecting accurate resistance standards to the Model 6517 and then verifying that the readings on the display fall within the required ranges. The following paragraphs discuss the required resistance standards, how to compute voltage source values, and provide detailed procedures for verifying accuracy of the ohms function.

NOTE

Ohms specifications are dervied from amps and voltage source specifications. Thus, it is not necessary to verify ohms separately. However, the following procedure is provided for those who wish to verify ohms accuracy.

Required standard resistors

Resistance standards required include:

- Resistance calibrator (2MΩ-200MΩ ranges)
- Model 5156 Electrometer Calibration Standard (2GΩ-200GΩ ranges)
- Characterized resistors (2TΩ-200TΩ ranges)

See Table 1-1 for detailed information on these recommended standard resistors.

Calculating ohms reading limits

Ohms reading limits must be calculated from the actual standard resistance value and the appropriate Model 6517 specificatins. For example, assume that the 2GΩ range is being tested, and the specifications are:

- Model 6517 2GΩ range accuracy: ±(0.225% of rdg + 1 count)
- 1GΩ resistor actual value: 1.025GΩ

Calculated reading limits are as follows:

Reading limits = 1.025GΩ ±[(1.025GΩ × 0.225%) + 10kΩ]
Reading limits = 1.025GΩ ± 2.31625MΩ
Reading limits = 1.02268GΩ to 1.02732GΩ

NOTE

Before performing the ohms verification procedures, calculate the reading limits for each range, and enter the limits where indicated in Table 1-9.

Selecting auto voltage source mode

Before performing the verification procedures, make sure the instrument is in the automatic voltage source mode. To do so, press CONFIG then R, and select VSOURCE in the displayed menu. Select AUTO in the VSOURCE SETTING menu, then press ENTER. Press EXIT to return to normal display.

Selecting internal voltage source connections

Before performing the verification procedures, make sure that the internal voltage connection is turned on. To do so, press CONFIG then OPER, then select METER-CONNECT in the CONFIGURE V-SOURCE menu. Press ENTER, then select ON in the SOURCE-METER CONNECT menu, then press ENTER again. Press EXIT to return to normal display.

2MΩ-200MΩ range verification

1. Connect the Model 6517 to the resistance calibrator, as shown in Figure 1-5.
2. Turn on the Model 6517 and the calibrator, and allow a one-hour warm-up period before making measurements.
3. Restore Model 6517 factory default conditions, as explained in paragraph 1.7.
4. Select the ohms function by pressing R.
5. Select the Model 6517 2MΩ range, and make sure the filter is enabled.
6. Set the calibrator resistance to a nominal 1.9MΩ resistance value.
7. Place the voltage source in operate.
8. Make sure zero check is disabled, and allow the reading to settle. Verify that the displayed ohms reading is within limits for the selected range listed in Table 1-9.
9. Repeat steps 5 through 8 for the 20MΩ and 200MΩ ranges.
10. Turn off the Model 6517 voltage source, then disconnect the resistance calibrator from the Model 6517.

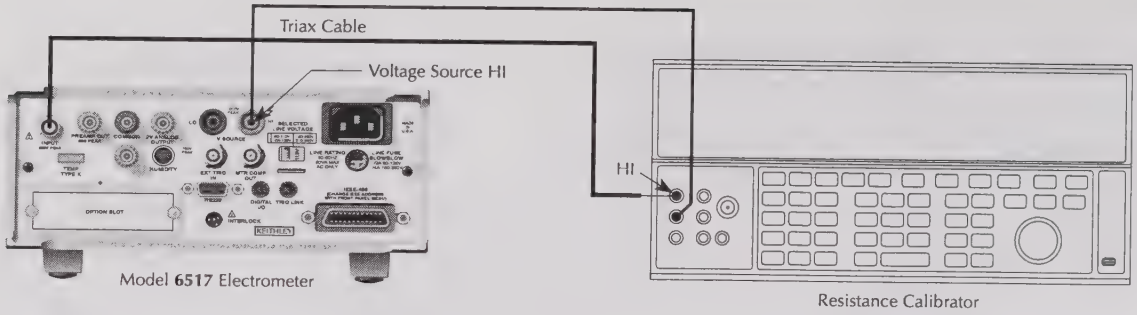

Figure 1-5
Connections for ohms verification (2MΩ–200MΩ ranges)

Table 1-9
Limits for ohms verification

Model 6517 range	Nominal resistance[1]	Reading limits[2] (1 year, 18°–28°C)
2MΩ	1.9MΩ	_____ to _____ MΩ
20MΩ	19MΩ	_____ to _____ MΩ
200MΩ	100MΩ	_____ to _____ MΩ
2GΩ	1GΩ	_____ to _____ GΩ
20GΩ	10GΩ	_____ to _____ GΩ
200GΩ	100GΩ	_____ to _____ GΩ
2TΩ	1TΩ	_____ to _____ TΩ
20TΩ	10TΩ	_____ to _____ TΩ
200TΩ	100TΩ	_____ to _____ TΩ

[1] Resistance calibrator used for 2MΩ-200MΩ ranges. Model 5156 Calibration Standard used for 2GΩ-200GΩ ranges. Characterized resistance standards used for 2TΩ-200TΩ ranges. Standards must be characterized to uncertainty at least four times better than equivalent Model 6517 specifications and mounted in shielded test box. (See Figure 1-8.)

[2]Reading limits calculated from actual resistance value and Model 6517 specifications. See text.

2GΩ-200GΩ range verification

1. Connect the nominal 1GΩ characterized resistor from the Model 5156 Calibration Standard to the Model 6517. (See Figure 1-6.)
2. Select the ohms function.
3. Place the voltage source in operate.
4. Select the 2GΩ range on the Model 6517.
5. Make sure that zero check is disabled, and allow the reading to settle.
6. Verify that the displayed reading is within the calculated limits listed in Table 1-9.
7. Repeat steps 4 through 6 for the 20GΩ and 200GΩ ranges.
8. Turn off the voltage source, then disconnect the calibration standard from the Model 6517.

2TΩ-200TΩ range verification

1. Connect the nominal 1TΩ characterized resistor to the Model 6517. (See Figure 1-7.)

NOTE

Standard resistors must be characterized to an uncertainty at least four times better than the equivalent Model 6517 accuracy specifications. These resistors must be mounted in specially shielded test fixtures to minimize noise. (See Figure 1-8 for details on test fixture construction.)

WARNING

Hazardous voltage (400V) will be used in the following steps. Do not touch connecting cables or test leads while the voltage source is in operate.

2. Select the 2TΩ range on the Model 6517.
3. Place the voltage source in operate.
4. Make sure that zero check is disabled, and allow the reading to settle.
5. Verify that the displayed reading is within the calculated limits listed in Table 1-9.
6. Repeat steps 2 through 5 for the 20TΩ and 200TΩ ranges.
7. Turn off the voltage source, then disconnect the standard resistor from the Model 6517.

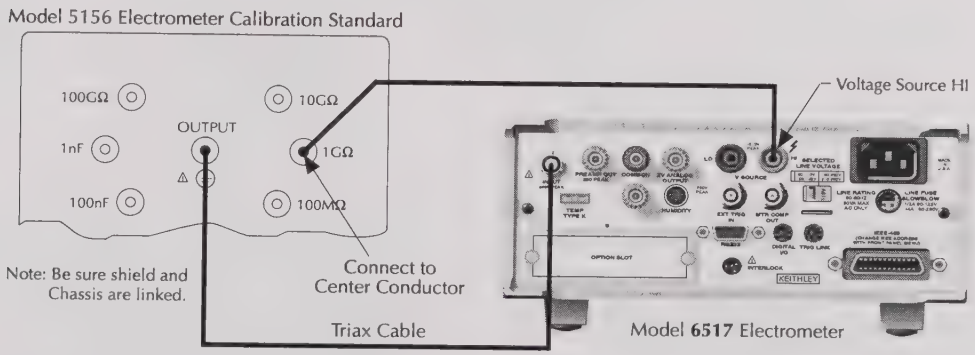

Figure 1-6
Connections for ohms verification (2GΩ–200GΩ ranges)

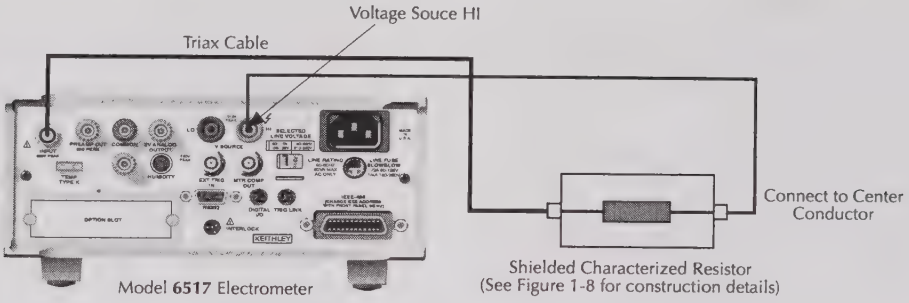

Figure 1-7
Connections for ohms verification (2TΩ–200TΩ ranges)

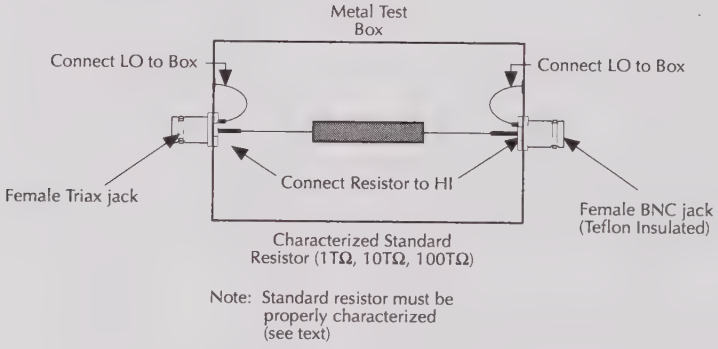

Figure 1-8
Shielded fixture construction

1.10 Voltage source verification

Voltage source output accuracy is checked by programming the voltage source to specific values and measuring the output voltage using a precision digital multimeter.

WARNING

Hazardous voltages will be used in the following steps. Use caution when working with hazardous voltages.

Proceed as follows to check the accuracy of the voltage source.

1. Turn on the Model 6517 and the DMM, and allow both instruments to warm up for at least one hour before making measurements.
2. Set the DMM to the DCV function, and enable autoranging.
3. Temporarily short the ends of the DMM test leads together, then enable the DMM REL mode. Leave REL enabled for the remainder of the test.
4. With the Model 6517 voltage source in standby (turned off), connect the DMM to the Model 6517 V-SOURCE OUT jacks, as shown Figure 1-9. Be sure to connect Model 6517 output HI to the DMM input HI, and output LO to input LO as shown.
5. Program the Model 6517 voltage source for an output value of 0.000V, and place the voltage source in operate.
6. Verify that the DMM reading is within the limits shown in the first line of Table 1-10.
7. Repeat steps 5 and 6 for each voltage output value listed in Table 1-10.
8. Repeat the procedure for negative output voltages with the same magnitudes listed in Table 1-10.

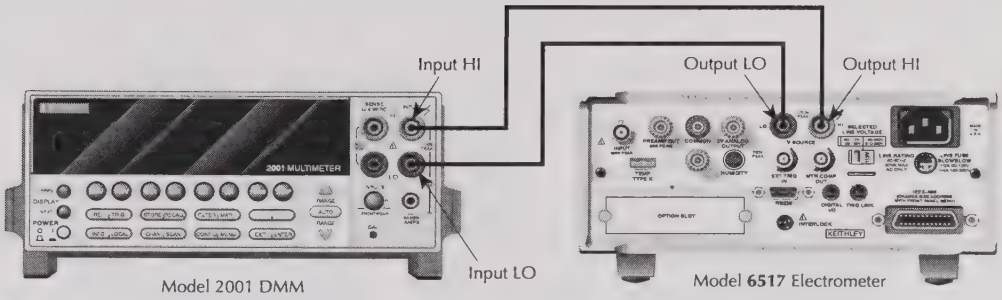

Figure 1-9
Connections for voltage source verification

Table 1-10
Limits for voltage source verification

6517 programmed source output	Voltage source output limits (1 year, 18° to 28°C)
0.000V	0.01V to +0.01V
25.000V	24.9525 to 25.0475
50.000V	49.915V to 50.085V
75.000V	74.8775V to 75.1225V
100.000V	99.84V to 100.16V
250.00V	249.525V to 250.475V
500.00V	499.15V to 500.85
750.00V	748.775V to 751.225V
1000.00V	998.4V to 1001.6V

NOTES:
1. Output limits shown are based only on Model 6517 one-year accuracy specifications and do include DMM uncertainty.
2. Repeat procedure for negative output voltages of same magnitude.

1.11 Temperature verification

Accuracy of the Model 6517 temperature measurement function is checked by connecting a thermocouple calibrator to the Model 6517 and then verifying that the temperature reading is within required limits.

Proceed as follows:

1. Connect the type K thermocouple calibrator to the Model 6517 EXT TEMP jack, as shown in Figure 1-10.
2. Turn on the Model 6517, and allow a one-hour warm-up period before making measurements.
3. Enable the Model 6517 external temperature display with the DISPLAY PREV key.
4. Set the thermocouple calibrator to -190°C (-5.72972mV), and allow the temperature reading to settle.
5. Verify that the Model 6517 temperature reading is within the limits stated in Table 1-11.
6. Repeat steps 6 and 7 for each calibrator temperature setting listed in Table 1-11.

Table 1-11
Reading limits for temperature verification

Calibration temperature	Calibration voltage	Temperature reading limits (1 year, 18° to 28°C)
-190°C	-5.72972mV	-191.5° to -188.5°C
0°C	0mV	-1° to +1°C
50°C	+2.0231mV	48.9° to 51.1°C
100°C	+4.0962mV	98.7° to 101.3°C
200°C	+8.1385mV	198.5° to 201.5°C
1300°C	+54.1377mV	1295.5° to 1304.5°C

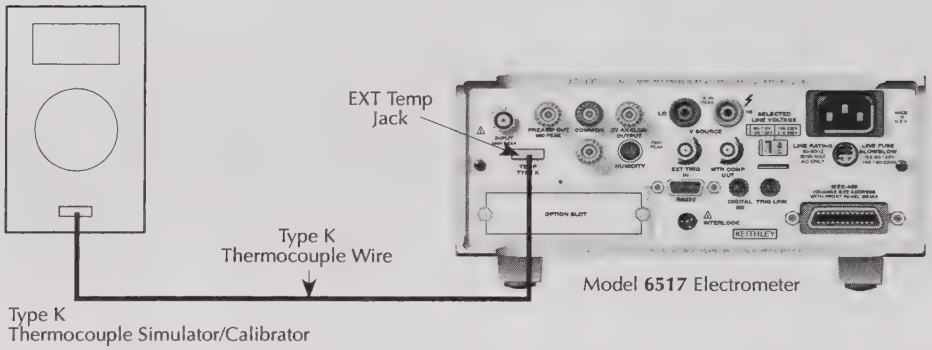

Figure 1-10
Connections for temperature verification

1.12 Humidity verification

Humidity measurement accuracy is checked by applying an accurate 0-1V DC voltage to the Model 6517 and verifying that the humidity readings are within specified limits.

Proceed as follows:

1. With the power off, connect the DC calibrator to the Model 6517 HUMIDITY connector, as shown in Figure 1-11. Use short lengths of solid #22AWG copper wire and alligator clips to make the connections, and be sure to observe proper polarity (calibrator HI to HUMIDITY +V and calibrator LO to HUMIDITY -V).
2. Turn on the power to the Model 6517 and the calibrator, and allow a one-hour warm-up period before making measurements.
3. Select the Model 6517 humidity display with DISPLAY PREV key.
4. Set the DC calibrator output to +0.2500V.

CAUTION

Do not exceed +2V input to the HUMIDITY jack, and be sure to observe proper polarity. Failure to do so may result in damage to the unit.

5. Allow the reading to settle, then verify that the Model 6517 humidity reading is within the limits summarized in Table 1-12.
6. Repeat steps 4 and 5 for each of the voltage/humidity reading combinations summarized in Table 1-12.

Table 1-12
Limits for humidity verification

Applied voltage	Humidity reading limits (1 year, 18° to 28°C)
0.0000V	0% to 1%
0.2500V	24% to 26%
0.5000V	49% to 51%
0.7500V	74% to 76%
1.0000V	99% to 101%

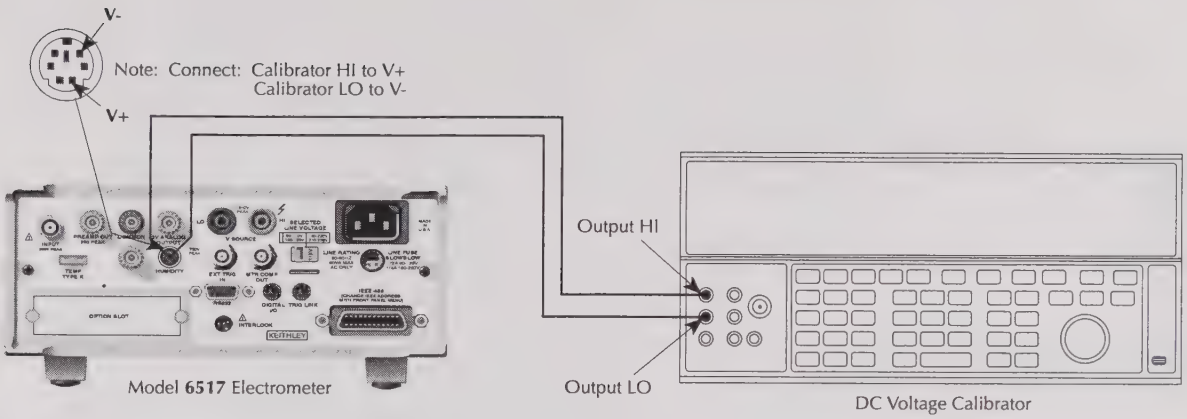

Figure 1-11
Connections for humidity verification

2
Calibration

2.1 Introduction

This section gives detailed procedures for calibrating the Model 6517. Basically, there are four parts to the comprehensive calibration procedure:

- Meter calibration (volts, amps, and coulombs)
- Temperature calibration
- Voltage source calibration
- Humidity calibration

Meter calibration requires accurate calibration equipment to supply precise DC voltages, DC currents, and charge values. Voltage source calibration requires an accurate DMM to measure DC voltages. Temperature calibration requires special temperature calibration equipment, while an accurate voltage source is needed for humidity calibration.

A single-point calibration feature is also available to allow you to calibrate a single function or range without having to perform the entire calibration procedure.

WARNING

The procedures in this section are intended only for qualified service personnel. Do not attempt to perform these procedures unless you are qualified to do so.

Section 2 includes the following information:

2.2 **Environmental conditions:** States the temperature and humidity limits for calibration.

2.3 **Warm-up period:** Discusses the length of time the Model 6517 should be allowed to warm up before calibration.

2.4 **Line power:** States the power line voltage limits when calibrating the unit.

2.5 **Recommended calibration equipment:** Summarizes all test equipment necessary for calibrating the Model 6517.

2.6 **Calibration lock:** Explains how to unlock calibration using the CAL switch.

2.7 **Calibration errors:** Discusses front panel error messages that might occur during calibration and also explains how to check for errors over the bus.

2.8 **Front panel calibration:** Covers calibration of all Model 6517 functions from the front panel. Functions calibrated include volts, amps, coulombs, the voltage source, as well as the temperature and humidity functions.

2.9 **IEEE-488 bus calibration:** Details calibration of all instrument functions over the IEEE-488 bus.

2.10 **Single-point calibration:** Outlines the basic methods for calibrating only a single function or range instead of having to go through the entire calibration procedure.

2.11 **Programming calibration dates:** Covers the procedures for programming the calibration date and calibration due date.

2.12 **Calibration temperature difference:** Discusses how to determine the internal temperature difference.

2.2 Environmental conditions

Voltage and 20μA-20mA current calibration procedures should be performed at an ambient temperature of 23° ±5°C, and at a relative humidity of less than 70% unless otherwise noted. 20pA-2μA current and coulombs calibration should be performed at 23°±3°C because of Model 5156 temperature restrictions.

NOTE

If the instrument is normally used over a different ambient temperature range, calibrate the instrument at the center of that temperature range.

2.3 Warm-up period

The Model 6517 must be allowed to warm up for at least one hour before calibration. If the instrument has been subjected to temperature extremes (outside the range stated in paragraph 2.2), allow additional time for internal temperatures to stabilize. Typically, it takes one additional hour to stabilize a unit that is 10°C (18°F) outside the specified temperature range.

The calibration equipment should also be allowed to warm up for the minimum period specified by the manufacturer.

2.4 Line power

The Model 6517 should be calibrated while operating from a line voltage within the range specified by the LINE VOLTAGE switch on the rear panel, at a line frequency of 50 or 60Hz.

2.5 Recommended calibration equipment

Table 2-1 summarizes test equipment recommended for calibrating the various Model 6517 functions. Alternate equipment may be used as long as that equipment has specifications equal to or better than those listed in the table.

NOTE

The Model 5156 Electrometer Calibration Standard is recommended for calibrating the 20pA-2μA amps ranges and all coulombs ranges. Alternate resistance and capacitance standards may be used as long as those standards are characterized to an uncertainty that is at least four times better than equivalent Model 6517 specifications.

Table 2-1
Recommended calibration equipment

Mfg.	Model	Description	Specifications*
Fluke	5700A	Calibrator	±5ppm basic uncertainty[1] DC Voltage: 1.9V: ±7ppm 19V: ±5ppm 190V: ±7ppm DC current: 19μA: ±576ppm 190μA: ±103ppm 1.9mA: ±55ppm 19mA: ±55ppm
Keithley	5156	Electrometer Calibration Standard	100MΩ[2] 1GΩ 10GΩ 100GΩ 1nF 100nF
Keithley	2001	Multimeter	1000V range: ±47ppm[3] 200V range: ±41ppm
Keithley	8607	Dual banana plug cable	
Keithley	4801	Low-noise coax cable	
Keithley	7078-TRX-BNC	Triax-to BNC adapter	
		BNC to dual banana plug adapter	
Keithley	237-ALG-2	Triax to alligator clips cable*	
Keithley	CAP-31	Triax shielding cap	
		Banana plugs to clip leads	
		2, 1" lengths of solid #20AWG wire	
Omega	CL-307-K	Type K thermocouple simulator/calibrator	0°C (0mV), 1232°C (50mV) ±0.04%

1. 90-day calibrator specifications shown include total absolute uncertainty at specified output.
2. Nominal values for calibration standards shown. Alternate standards may be used if those standards are characterized to uncertainty at least four times better than equivalent Model 6517 specifications.
3. 1-year multimeter specifications are for full-range input.

*Short red and black clips together to make triax short.

2.6 Calibration lock

2.6.1 Unlocking calibration

Before performing calibration, you must first unlock calibration by momentarily pressing in on the recessed CAL switch. The instrument will display the following message:

CALIBRATION UNLOCKED
Comprehensive cal can now be run

If you attempt calibration without performing the unlocking procedure, the following message will be displayed:

CALIBRATION LOCKED
Press the CAL switch to unlock

2.6.2 IEEE-488 bus calibration lock status

You can determine the status of the calibration lock over the bus by using the appropriate query. To determine calibration lock status, send the following query:

:CAL:PROT:SWIT?

The instrument will respond with the calibration lock status:

0: comprehensive calibration locked
1: comprehensive calibration unlocked

Refer to Section 3 for more details on calibration commands.

2.7 Calibration errors

The Model 6517 checks for errors after each calibration step, minimizing the possibility that improper calibration may occur due to operator error. The following paragraphs discuss both front panel and bus error reporting.

2.7.1 Front panel error reporting

If an error is detected during comprehensive calibration, the instrument will display an appropriate error message (see Appendix B).

2.7.2 IEEE-488 bus error reporting

You can detect errors over the bus by testing the state of EAV (Error Available) bit (bit 2) in the status byte. (Use the *STB? query or serial polling to request the status byte.) If you wish to generate an SRQ (Service Request) on errors, send "*SRE 4" to the instrument to enable SRQ on errors.

You can query the instrument for the type of error by using the appropriate calibration error query. The Model 6517 will respond with the error number and a text message describing the nature of the error. Paragraph 3.8 in Section 3 discusses error queries, and Appendix B summarizes calibration errors.

2.8 Front panel calibration

The front panel comprehensive calibration procedure calibrates meter functions (volts, amps, and coulombs) as well as the voltage source, and the temperature and humidity functions. Calibration should be performed at least once a year.

The procedures below will take you step-by-step through complete Model 6517 calibration from the front panel and include the following:

- Meter calibration (volts, amps, coulombs)
- Temperature calibration
- Voltage source calibration
- Humidity calibration

NOTE

If you wish to calibrate only a single function or range, refer to the single-point calibration procedures covered in paragraph 2.10.

2.8.1 Front panel calibration summary

Table 2-2 summarizes the front panel calibration procedure.

Table 2-2
Front panel calibration summary

Step	Description	Equipment/connections
1	Warm-up, unlock calibration	None
2	Offset voltage adjustment	Triax shorting cap to INPUT jack
3	Bias current adjustment	Triax shielding cap to INPUT
4	Zero voltage calibration	Triax short to INPUT
5	+2V calibration	Voltage calibrator to INPUT
6	-2V calibration	Voltage calibrator to INPUT
7	+20V calibration	Voltage calibrator to INPUT
8	-20V calibration	Voltage calibrator to INPUT
9	+200V calibration	Voltage calibrator to INPUT
10	-200V calibration	Voltage calibrator to INPUT
11	Zero current calibration	Triax shield to INPUT
12	+20pA calibration	Voltage/cal unit to INPUT
13	-20pA calibration	Voltage/cal unit to INPUT
14	+200pA calibration	Voltage/cal unit to INPUT
15	-200pA calibration	Voltage/cal unit to INPUT
16	+2nA calibration	Voltage/cal unit to INPUT
17	-2nA calibration	Voltage/cal unit to INPUT
18	+20nA calibration	Voltage/cal unit to INPUT
19	-20nA calibration	Voltage/cal unit to INPUT
20	+200nA calibration	Voltage/cal unit to INPUT
21	-200nA calibration	Voltage/cal unit to INPUT
22	2μA calibration	Voltage/cal unit to INPUT
23	-2μA calibration	Voltage/cal unit to INPUT
24	20μA calibration	Current calibrator to INPUT
25	-20μA calibration	Current calibrator to INPUT
26	200μA calibration	Current calibrator to INPUT
27	-200μA calibration	Current calibrator to INPUT
28	+2mA calibration	Current calibrator to INPUT
29	-2mA calibration	Current calibrator to INPUT
30	+20mA calibration	Current calibrator to INPUT
31	-20mA calibration	Current calibrator to INPUT
32	2nC zero calibration	Voltage/cal unit to INPUT
33	+2nC calibration	Voltage/cal unit to INPUT
34	-2nC calibration	Voltage/cal unit to INPUT
35	20nC zero calibration	Voltage/cal unit to INPUT
36	+20nC calibration	Voltage/cal unit to INPUT
37	-20nC calibration	Voltage/cal unit to INPUT
38	200nC zero calibration	Voltage/cal unit to INPUT
39	+200nC calibration	Voltage/cal unit to INPUT
40	-200nC calibration	Voltage/cal unit to INPUT
41	2μC zero calibration	Voltage/cal unit to INPUT
42	+2μC calibration	Voltage/cal unit to INPUT
43	-2μC calibration	Voltage/cal unit to INPUT
44	0mV (0°C) temperature calibration	Thermocouple cal to EXT TEMP
45	50mV (1232°C) temperature calibration	Thermocouple cal to EXT TEMP
46	0V 100V range voltage source cal	DMM to V SOURCE OUT
47	40V voltage source calibration	DMM to V SOURCE OUT
48	100V voltage source calibration	DMM to V SOURCE OUT

Table 2-2
Front panel calibration summary (cont.)

Step	Description	Equipment/connections
49	-100V voltage source calibration	DMM to V SOURCE OUT
50	0V 1000V range voltage source cal	DMM to V SOURCE OUT
51	400V voltage source calibration	DMM to V SOURCE OUT
52	1000V voltage source calibration	DMM to V SOURCE OUT
53	-1000V voltage source calibration	DMM to V SOURCE OUT
54	Humidity 0V calibration	DC calibrator to HUMIDITY
55	Humidity 0.5V calibration	DC calibrator to HUMIDITY
56	Humidity 1V calibration	DC calibrator to HUMIDITY

2.8.2 Front panel calibration procedure

The paragraphs that follow will take you step-by-step the comprehensive calibration procedure, which calibrates all Model 6517 functions, including volts, ohms, amps, the voltage source, temperature, and humidity.

Step 1: Prepare the Model 6517 for Calibration

1. With the power off, connect the Model 5156 Electrometer Calibration Standard to the rear panel DIGITAL I/O jack using the supplied cable (see Figure 2-1). Note that the calibration unit is used to calibrate the 20pA - 2μA amps ranges as well as all coulombs ranges.

NOTE

The calibration standard must be connected to the Model 6517 DIGITAL I/O port in order to operate properly. Do not connect any equipment except the Model 5156 Calibration Standard to the Model 6517 DIGITAL I/O port during calibration. Other equipment may be affected by digital signals present during calibration.

2. Turn on the power, and allow the Model 6517 to warm up for at least one hour before performing calibration.
3. Unlock comprehensive calibration by briefly pressing in on the recessed front panel CAL switch, and verify that the following message is displayed:

CALIBRATION UNLOCKED
Comprehensive cal can now be run

4. Enter the front panel calibration menu as follows:
   A. From normal display, press MENU. The instrument will display the following:

MAIN MENU
SAVESETUP COMMUNICATION CAL

   B. Select the CAL/CAL-OPT/CONTROL menu. The instrument will then prompt you as to whether or not you intend to use the calibration standard:

USE CAL OPTION
YES NO

   C. Select YES, then press ENTER followed by EXIT.

NOTE

The calibration option must be enabled in order to use the recommended calibration standard. See paragraph 2.11 for details.

   D. The unit will then display the following prompt:

PERFORM CALIBRATION
COMPREHENSIVE POINT-CALS ▶

   E. Select COMPREHENSIVE, then press ENTER.
5. At this point, the instrument will display the following message to indicate that you have chosen the full calibration procedure:

FULL CALIBRATION
Press ENTER to continue; EXIT to ▶
◀ abort calibration sequence

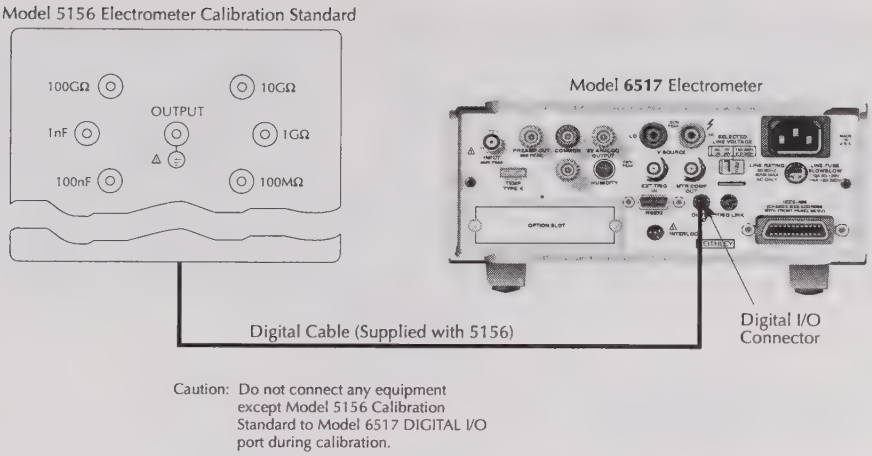

Figure 2-1
Calibration unit connections

Step 2: Offset Calibration

1. Press ENTER. The instrument will display the following prompt.

   CONNECT TRIAX SHORT
   ENTER to continue; EXIT to abort

2. Connect the shorted triax cable (connect red and black clips together) to the instrument INPUT jack.
3. Press ENTER. The instrument will then begin voltage offset calibration. While calibration is in progress, the following will be displayed:

   Performing V offset calibration

4. When the voltage offset calibration step is completed, the following message will be displayed:

   CONNECT TRIAX CAP
   ENTER to continue, EXIT to abort

5. Disconnect the triax short from the INPUT jack, and connect the triax shielding (non-shorting) cap to the INPUT jack in its place.
6. Press ENTER to begin the bias current calibration step. During this step, the instrument will display:

   Performing I Bias calibration

Step 3: Volts Calibration

1. Remove the triax shielding cap from the INPUT jack, and connect the DC voltage calibrator to the INPUT jack in its place, as shown in Figure 2-2. Note that these connections are made using a low-noise coax cable, a triax-to-BNC adapter, and a BNC-to-dual banana plug adapter.
2. Following the zero check calibration step, the instrument will prompt you to connect 0V DC:

   CONNECT 0 V
   ENTER to continue; EXIT to abort

3. Set the DC voltage calibrator output to 0.00000V DC, and allow a short time period for settling.
4. Press ENTER to continue. During 0V DC calibration, the Model 6517 will display the following:

   Performing 0V calibration

5. Next, the unit will prompt for a 1.9V DC input:

   CONNECT 2.000000 V
   ENTER to continue; EXIT to abort

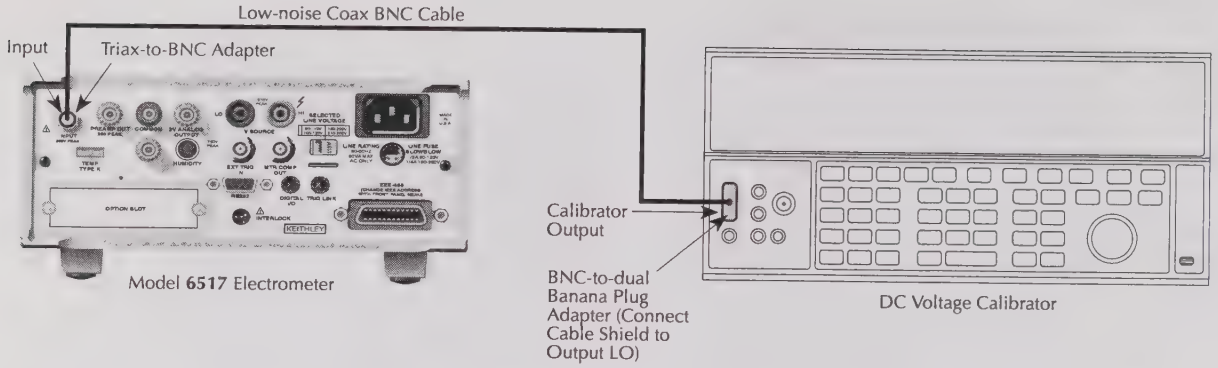

Figure 2-2
Connections for DC volts calibration

6. Set the output of the DC voltage calibrator to exactly +1.900000V, then press the Model 6517 ENTER key. The instrument will then prompt for the exact calibration value:

   1.9000000 V
   Use ▲, ▼, ◄ , ► ,ENTER,EXIT or INFO

7. If necessary, use the range and cursor keys to set the displayed value to the exact calibrator voltage value.

   NOTE

   For optimum accuracy, it is recommended that you use the default values throughout the entire calibration procedure.

8. After setting the calibration value, press ENTER to continue. During this step, the instrument will display the following:

   Performing 2 V Calibration

9. Next, the unit will prompt you to apply -1.9V:

   CONNECT -2.000000 V
   ENTER to continue; EXIT to abort

10. Set the DC voltage calibrator output to exactly -1.9000000V DC, then press ENTER. Again, the unit will prompt you for the actual applied voltage:

    -1.9000000 V
    ENTER to continue; EXIT to abort

11. Again, set the displayed value to agree with the calibrator voltage, then press ENTER. During this step, the unit will display the following:

    Performing -2V Calibration

12. Repeat steps 5 through 11 for 20V and 200V ranges using the values summarized in Table 2-3. After performing all volts calibration points, continue with amps calibration detailed below.

Table 2-3
Volts calibration summary

6517 range	Applied calibration voltage	Comments
—	0.0000000V DC	Volts zero cal
2V	+1.9000000V DC	Positive 95% of full range
2V	-1.9000000V DC	Negative 95% of full range
20V	+19.000000V DC	Positive 95% of full range
20V	-19.000000V DC	Negative 95% of full range
200V	+190.00000V DC	Positive 95% of full range
200V	-190.00000V DC	Negative 95% of full range

Step 4: Amps Calibration

1. At this point, the Model 6517 will display the following message:

   CONNECT TRIAX CAP
   ENTER to continue; EXIT to abort

2. Connect the triax shielding cap to the INPUT jack.
3. Press the Model 6517 ENTER key. During this calibration step, the instrument will display the following:

   Performing 0 A Calibration

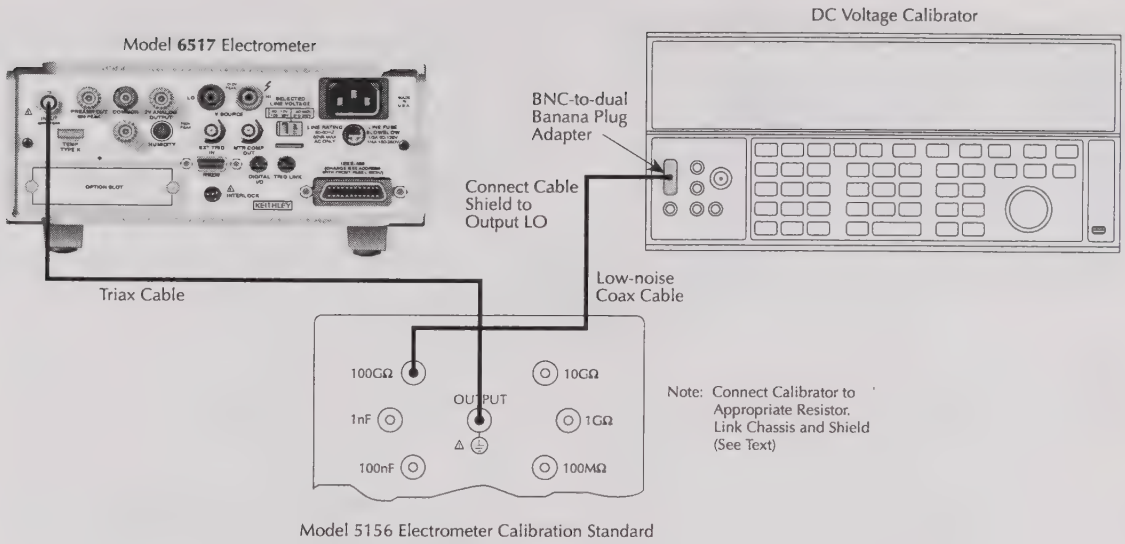

Figure 2-3
Connections for 20pA–2μA range calibration

4. Connect the Model 5156 Electrometer Calibration Standard and the DC voltage calibrator to the Model 6517 INPUT jack, as shown in Figure 2-3. Initially, make connections to the 100GΩ resistance in the standards box.
5. After the zero current calibration step, the instrument will prompt you as follows:

   CONNECT 2V to 100G
   ENTER to continue; EXIT to abort

6. Set the DC voltage calibrator to exactly 1.900000V DC. Make sure the 100GΩ resistor in the calibration standard is connected, then press the Model 6517 ENTER key. The instrument will prompt for the exact calibration value:

   1.9000000 V
   Use ▲, ▼, ◄ , ► ,ENTER,EXIT or INFO

NOTE

For all calibration steps that involve the Model 5156, you can set calibration values in either one of two ways: (1) set the calibrator output to agree with the displayed value, or (2) adjust the display to agree with the calibrator value.

7. Adjust the calibrator voltage to agree with the exact display value, then press the ENTER key. During this step, the instrument will display the following:

   Performing 20 pA cal

8. Next, the instrument will prompt you as follows:

   CONNECT -2V to 100G
   ENTER to continue; EXIT to abort

9. Press the Model 6517 ENTER key. The instrument will prompt for the exact calibration value:

   -1.9000000 V
   Use ▲, ▼, ◄ , ► ,ENTER,EXIT or INFO

10. Set the calibrator output to the display value, then press the ENTER key. The unit will display the following during this calibration step:

    Performing -20 pA Calibration

11. Repeat steps 5 through 10 for the 200pA through 2μA ranges using the voltages and resistance standards summarized in Table 2-4.
12. Disconnect the calibration standard and voltage calibrator from the instrument, and connect the DC current calibrator directly to the Model 6517 INPUT jack (see Figure 2-4).
13. At this point, the Model 6517 will display the following:

    CONNECT 19.00000 μA
    ENTER to continue; EXIT to abort

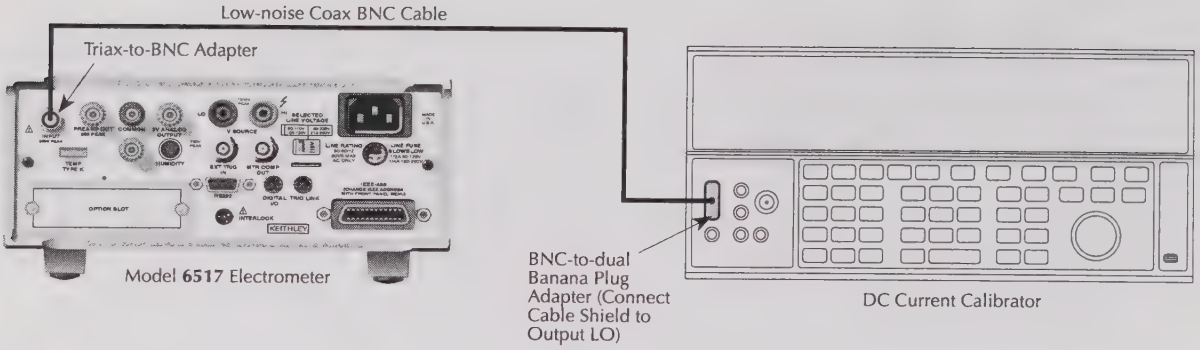
Low-noise Coax BNC Cable
Triax-to-BNC Adapter
Model 6517 Electrometer
BNC-to-dual Banana Plug Adapter (Connect Cable Shield to Output LO)
DC Current Calibrator

Figure 2-4
Connections for 20μA–20mA range calibration

Table 2-4
Amps calibration summary (20pA–2μA ranges)

6517 range	Calibrator voltage	Resistance[1] standard	Nominal[2] current
—	0.00000V	100GΩ	0pA
20pA	1.900000V	100GΩ	19pA
20pA	-1.900000V	100GΩ	-19pA
200pA	1.900000V	10GΩ	190pA
200pA	-1.900000V	10GΩ	-190pA
2nA	1.900000V	1GΩ	1.9nA
2nA	-1.900000V	1GΩ	-1.9nA
20nA	1.900000V	100MΩ	19nA
20nA	-1.900000V	100MΩ	-19nA
200nA	19.00000V	100MΩ	190nA
200nA	-19.00000V	100MΩ	-190nA
2μA	190.0000V	100MΩ	1.9μA
2μA	-190.0000V	100MΩ	-1.9μA

[1]Actual resistance standard value determined from calibration data supplied with standard.
[2]Actual calibration current : I = V/R, where is the calibration voltage, and R is the actual resistance standard value. When using the Model 5156 Electrometer Calibration Standard, the Model 6517 automatically calculates the actual current from the actual standard value and the calibrator voltage.

14. Press the Model 6517 ENTER key. The unit will prompt for the exact calibration value:

    19.000000 μA
    Use ▲, ▼, ◄ , ► ,ENTER,EXIT, or INFO

    Set the calibrator output to exactly +19.000000μA DC, make certain that the displayed value agrees with the applied current, then press the ENTER key. During this calibration phase, the unit will display the following:

    Performing 20 μA cal

16. After this step has been completed, the instrument will prompt for the next calibration value:

    CONNECT -20.00000 μA
    ENTER to continue; EXIT to abort

17. Set the calibrator output to exactly -19.00000μA DC, then press the Model 6517 ENTER key. The unit will then display the actual calibration value:

    -19.000000 μA
    Use ▲, ▼, ◄ , ► ,ENTER,EXIT, or INFO

18. If necessary, adjust the displayed value to agree with the calibrator current, then press the ENTER key. During this calibration step, the unit will display the following message:

    Performing -20 μA cal

19. Repeat steps 13 through 18 for the 200μA through 20mA ranges using the calibrator current values summarized in Table 2-5.

Table 2-5
Amps calibration summary (20μA-20mA ranges)

6517 range	Calibration current
20μA	19.00000μA
20μA	-19.00000μA
200μA	190.0000μA
200μA	-190.0000μA
2mA	1.900000mA
2mA	-1.900000mA
20mA	19.00000mA
20mA	-19.00000mA

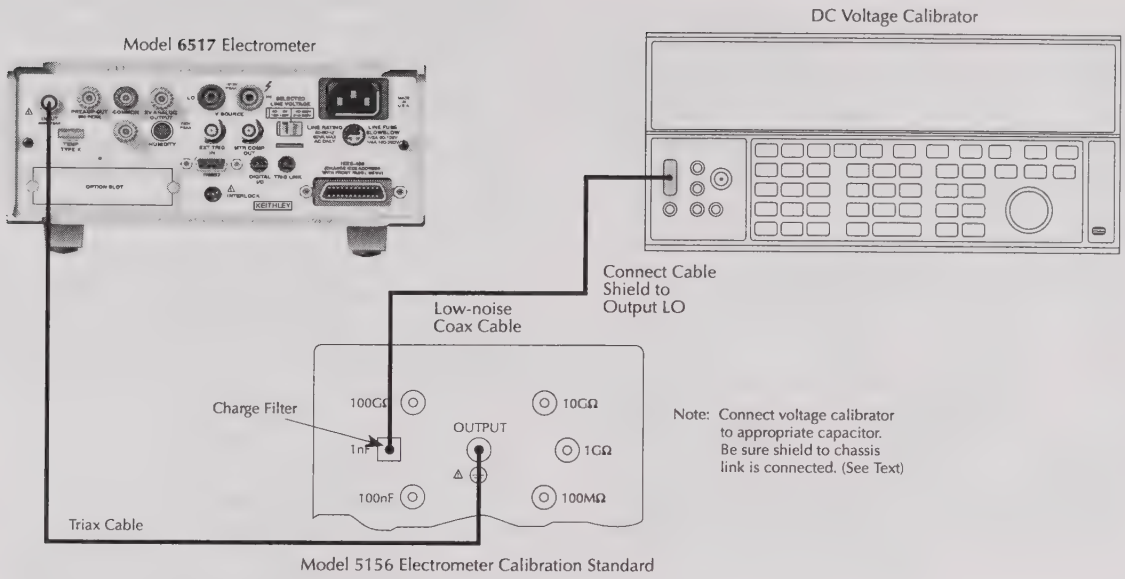

Figure 2-5
Connections for coulombs calibration

Step 5: Coulombs Calibration

1. Connect the calibration standard and DC voltage calibrator to the Model 6517 INPUT jack, as shown in Figure 2-5. Initially, make connections to the 1nF capacitor in the standards box.
2. Set the output voltage of the DC calibrator to 0.00000V.
3. Press the ENTER key to begin zero check A calibration. During this step, the instrument will display:

   Performing 2nC zero check A cal

4. After zero cal, the instrument will display the following:

   CONNECT 2V to 1000pF
   ENTER to continue; EXIT to abort

5. Press the ENTER key, and note that the instrument displays the actual calibration value:

   +1.9000000 V
   Use ▲, ▼, ◄ , ► ,ENTER,EXIT or INFO

6. Set the DC calibrator voltage to +1.9000000V DC. If necessary, set the displayed calibration value to agree with the actual calibrator voltage, then press the ENTER key. During this step, the instrument will display the following:

   Performing 2 nC cal

7. Set the calibrator output to 0V, then press the ENTER key to automatically perform 2nC zero check B calibration.
8. After zero check calibration, the instrument will prompt you for the next calibration step:

   CONNECT -2V to 1000p
   ENTER to continue; EXIT to abort

9. Set the DC voltage calibrator to -1.900000V, and allow sufficient time for settling.
10. Press the ENTER key, and note that the instrument displays the exact calibration value:

    -1.9000000 V
    Use ▲, ▼, ◄ , ► ,ENTER,EXIT or INFO

11. If necessary, adjust the display to agree with the exact calibration value.
12. Press the Model 6517 ENTER key. During this calibration phase, the instrument will display the following:

    Performing -2nC cal

13. Repeat steps 4 through 12 for the remaining coulombs ranges using the voltage values and capacitance standards values summarized in Table 2-6.

Table 2-6
Coulombs calibration summary

6517 range	Calibration voltage	Standard[1] capacitance	Nominal[2] charge
2nC	1.900000V	1nF	1.9nC
2nC	-1.900000V	1nF	-1.9nC
20nC	19.00000V	1nF	19nC
20nC	-19.00000V	1nF	-19nC
200nC	1.900000V	100nF	190nC
200nC	-1.900000V	100nF	-190nC
2μC	19.00000V	100nF	1.9μC
2μC	-19.00000V	100nF	-1.9μC

[1]Nominal capacitance standard shown. Refer to calibration data for actual value.
[2]Charge calculated from: Q = CV, where C is capacitance standard value, and V is the calibrator voltage. When using the Model 5156 Electrometer Calibration Standard, the Model 6517 automatically calculates the charge from the actual capacitance value and the applied calibrator voltage.

Step 6: Temperature Calibration

1. Connect the thermocouple calibrator to the Model 6517 EXT TEMP jack, as shown in Figure 2-6.
2. At the end of the coulombs calibration phase, the instrument will prompt you for the first temperature calibration point:

   CONNECT 0V/0°C
   ENTER to continue; EXIT to abort

3. Set the thermocouple calibrator output to 0°C (0mV), then press the Model 6517 ENTER key. During this step, the instrument will display the following:

   Performing 0 V Temp Calibration

4. Next, the instrument will prompt you for the 1232°C (50mV) calibration point:

   CONNECT 50mV/1232°C

5. Set the thermocouple calibrator output to 1232°C (+50mV), then press the Model 6517 ENTER key. During this step, the instrument will display the following message:

   Performing 50mV Temp Calibration

Step 7: Voltage Source Calibration

WARNING

Hazardous voltages will be present when performing the following steps. Avoid touching terminals while performing these procedures.

1. After temperature calibration has been completed, the instrument will prompt you to connect the voltmeter to the voltage source output jacks:

   V-SOURCE CALIBRATION
   Connect Vsource to voltmeter

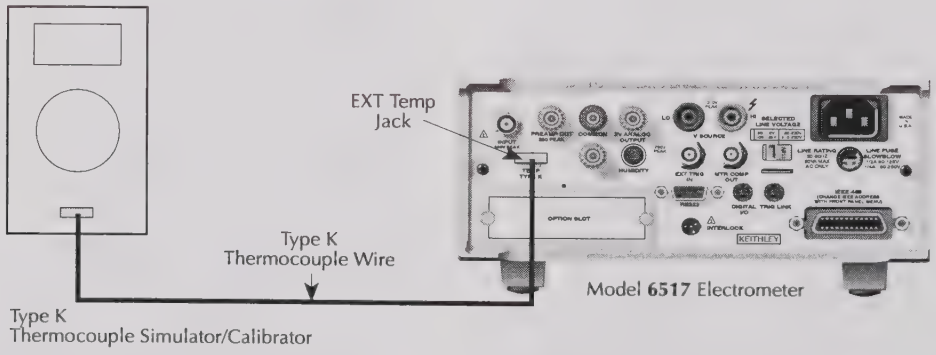

Figure 2-6
Connections for temperature calibration

2. Select the DCV function and the auto-range mode on the DMM.
3. Temporarily short the ends of the DMM test leads, then enable the DMM REL mode. Leave REL enabled for the remainder of the tests.
4. Connect the DMM to the V SOURCE OUT jacks, as shown in Figure 2-7.
5. Press ENTER. The Model 6517 will prompt you for 0V output:

   V-SOURCE 0: 100V RNG
   Press ENTER to output 0V

6. Press ENTER, and note that the instrument prompts for the actual DMM reading:

   DMM RDG: +0.00000 V
   Use ▲, ▼, ◄ , ► ,ENTER,EXIT or INFO

7. Adjust the Model 6517 display so that it agrees exactly with the voltage reading on the DMM, then press the ENTER key.
8. Repeat steps 6 and 7 for each voltage source output value summarized in Table 2-7. For each step, be sure to adjust the Model 6517 display to agree exactly with the DMM reading.

Table 2-7
Voltage source calibration summary

Nominal output	Display prompt	Comments
0V	DMM RDG: +0.00000 V	100V range calibration
+40V	DMM RDG: +40.0000 V	
+100V	DMM RDG: +100.0000 V	
-100V	DMM RDG: -100.0000 V	
0V	DMM RDG: 0.00000 V	1000V range calibration
+400V	DMM RDG: +400.000 V	
+1000V	DMM RDG: +1000.000 V	
-1000V	DMM RDG: -1000.000 V	

NOTE: For each calibration step, adjust the displayed value to agree with the DMM reading.

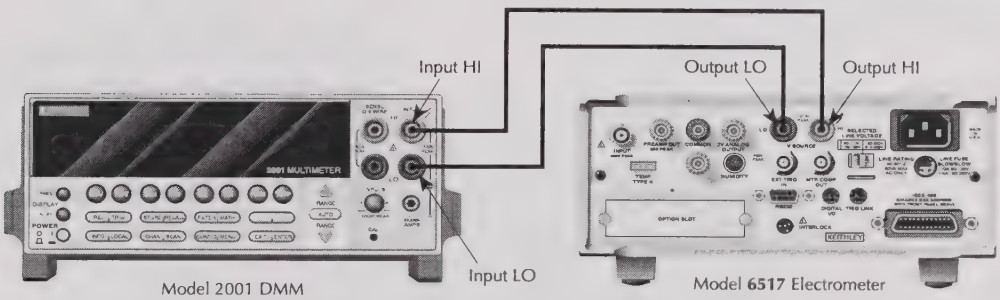

Figure 2-7
Connections for voltage source calibration

Step 8: Humidity Calibration

1. At the end of the voltage source calibration phase, the instrument will prompt you for humidity calibration:

   HUMIDITY CALIBRATION
   Connect 0 V to humidity input

2. Connect the DC voltage calibrator to the rear panel HUMIDITY jack, as shown in Figure 2-8.
3. Set the DC calibrator output to 0.00000V, then press the Model 6517 ENTER key.
4. Repeat steps 2 and 3 for 0.5V and 1V input, as summarized in Table 2- 8.

Table 2-8
Humidity calibration summary

Calibration point	Calibrator voltage
0V	0.00000V
0.5V	0.50000V
1V	1.00000V

Step 9: Enter Calibration Dates

1. At the end of humidity calibration steps, the unit will prompt you to enter the calibration date:

   CAL DATE: mm/dd/yy

   Note that the present date is used as the default displayed date, which is displayed in mm (month), dd (date), yy (year) format.
2. Change the displayed date to today's date, then press the ENTER key. You will then be given an opportunity to confirm or change your selection.
3. The unit will then prompt for the next calibration date:

   NEXT CAL: mm/dd/yy

   The default displayed next calibration date is one year from today's date and is displayed in mm (month), dd (date), yy (year) format.
4. Set the next calibration date to the desired value, then press ENTER. Again, you will be given the opportunity to confirm or change the date.

Step 10: Complete Calibration

At the end of a successful calibration procedure, the instrument will display the following:

CALIBRATION SUCCESS
ENTER to save; EXIT to abort

As displayed, press the ENTER key to save new calibration constants, or press EXIT to abort the calibration procedure.

NOTE

If you abort calibration, constants derived during the present calibration procedure will not be saved, and previous calibration values will be retained.

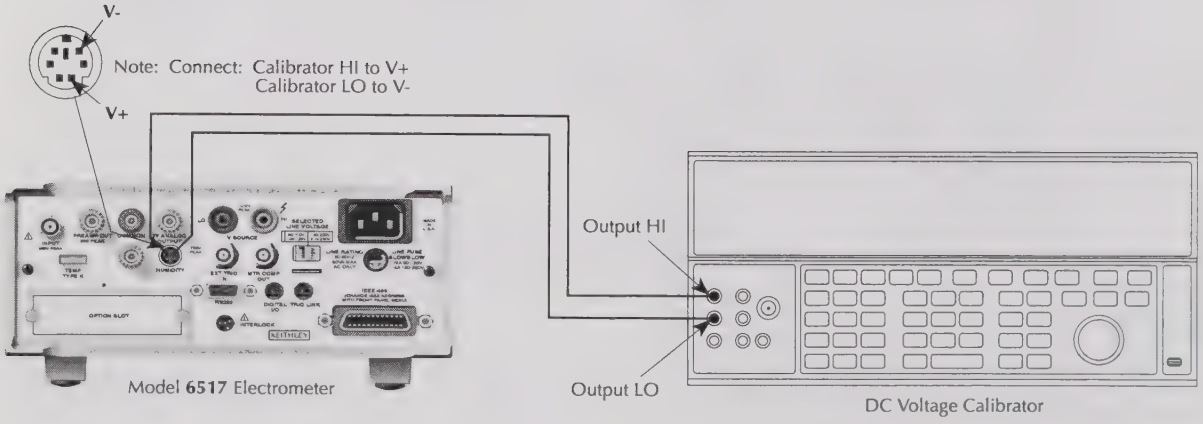

Figure 2-8
Connections for humidity calibration

2.9 IEEE-488 bus calibration

2.9.1 Calibration commands

Refer to Section 3 or Appendix C for a complete listing of calibration commands. Section 3 also provides a detailed discussion of each command.

2.9.2 IEEE-488 bus comprehensive calibration procedure

Follow the procedure outlined below to perform comprehensive calibration over the IEEE-488 bus. The bus commands and appropriate parameters are separately summarized for each step.

Procedure

Step 1: Prepare the Model 6517 for Calibration

1. Connect the Model 6517 to the IEEE-488 bus of the computer using a shielded IEEE-488 cable such as the Keithley Model 7007.
2. Connect the calibration standard to the Model 6517 DIGITAL I/O jack (see Figure 2-1).

NOTE

The calibration standard must be connected to the DIGITAL I/O port in order to operate properly. Do not connect any equipment except the Model 5156 Electrometer Calibration Standard to the Model 6517 DIGITAL I/O port during calibration. Digital signals present during calibration may affect other equipment.

3. Turn on the power, and allow the Model 6517 to warm up for at least one hour before performing calibration.
4. Unlock calibration by briefly pressing in on the recessed front panel CAL switch, and verify that the following message is displayed:

CALIBRATION UNLOCKED
Comprehensive cal can now be run

NOTE

You can query the instrument for the state of the comprehensive CAL switch by using the following query:

:CAL:PROT:SWIT?

A returned value of 1 indicates that calibration is locked, while a returned value of 0 shows that calibration is unlocked.

5. Make sure the primary address of the Model 6517 is the same as the address specified in the program you will be using to send commands. (Use the MENU key and the COMMUNICATION menu to access the IEEE-488 address.)

Step 2: Offset Calibration

Perform the steps below to perform the various offset calibration steps. Table 2-9 summarizes these steps.

1. Connect the shorted triax cable (connect red and black clips) to the instrument INPUT jack.
2. Send the following command over the bus:

:CAL:UNPR:VOFF

Wait until the instrument completes this step before continuing. (See paragraph 3.9.)

3. Disconnect the triax shorting cap from the INPUT jack, and connect the triax shielding (non-shorting) cap to the INPUT jack in its place.
4. Send the following command to the instrument:

:CAL:UNPR:IOFF

Wait until the instrument completes this step before continuing.

Step 3: Initiate Calibration

Send the following command over the bus to initiate calibration:

:CAL:PROT:INIT

Table 2-9
Offset calibration steps

Step	Bus command	Connections*
Offset voltage	:CAL:UNPR:VOFF	Triax shorting cable
Bias current	:CAL:UNPR:IOFF	Triax shielding cap

* Connect indicated triax cap or cable to INPUT jack.

Step 4: Volts Calibration

Perform the steps below to calibrate the Model 6517 volts function. Table 2-10 summarizes these steps.

1. Remove the triax shielding cap from the INPUT jack, and connect the DC voltage calibrator to the INPUT jack in its place (see Figure 2-2).
2. Set the DC voltage calibrator output to 0.00000V DC, and allow a short time period for settling.
3. Send the following command to the instrument:

   :CAL:PROT:VZERO2

   NOTE

   Throughout the entire calibration procedure, be sure to allow the instrument to complete each command before sending the next one. See paragraph 3.9 in Section 3 for information on how to determine when each command has been completed.

4. Set the calibrator output voltage to +1.900000V, and allow time for settling.
5. Send the following command to the instrument:

   :CAL:PROT:V2 1.9

   NOTE

   If you are using calibration values other than those given, be sure to change command parameters accordingly. However, for optimum accuracy, it is recommended that you use the stated calibration values throughout the entire calibration procedure.

6. Set the calibrator output voltage to -1.90000V, and allow for settling time.
7. Send the following command:

   :CAL:PROT:VN2 -1.9

8. Repeat steps 3 through 7 for the +20V, -20V, +200V, and -200V steps using the calibrator voltages and commands summarized in Table 2-10. For each step, be sure to set the calibrator voltage properly, and use the correct bus command.

Table 2-10
IEEE-488 bus volts function calibration summary

Volts calibration step	Calibrator voltage	Bus commands*
2V range zero	0.000000V DC	:CAL:PROT:VZERO2
+2V step	+1.900000V DC	:CAL:PROT:V2 1.9
-2V step	-1.900000V DC	:CAL:PROT:VN2 -1.9
20V range zero	0.000000V DC	:CAL:PROT:VZERO20
+20V step	+19.00000V DC	:CAL:PROT:V20 19
-20V step	-19.00000V DC	:CAL:PROT:VN20 -19
200V range zero	0.000000V DC	:CAL:PROT:VZERO200
+200V step	+190.0000V DC	:CAL:PROT:V200 190
-200V step	-190.0000V DC	:CAL:PROT:VN200 -190

* Bus command parameters based on recommended calibrator voltages. Substitute appropriate numeric parameter if using different calibrator voltages.

Step 5: Amps Calibration

Perform the following steps to calibrate the amps function. Table 2-11 and Table 2-12 summarize these steps.

1. Connect the triax shielding cap to the INPUT jack.
2. Send the following commands to the instrument:

   :CAL:PROT:AZERO20P
   :CAL:PROT:AZERO200P
   :CAL:PROT:AZERO2N
   :CAL:PROT:AZERO20N
   :CAL:PROT:AZERO200N
   :CAL:PROT:AZERO2U
   :CAL:PROT:AZERO20U
   :CAL:PROT:AZERO200U
   :CAL:PROT:AZERO2M
   :CAL:PROT:AZERO20M

3. Connect the Model 5156 Calibration Standard and the DC voltage calibrator to the Model 6517 INPUT jack (see Figure 2-3). Initially, make connections to the 100GΩ resistance in the standards box.
4. Set the DC voltage calibrator to exactly +1.900000V DC, then send the following command to the instrument:

   :CAL:PROT:A20PCARD 1.9

5. Set the DC voltage calibrator output to -1.900000V DC, then send the following command to the unit:

   :CAL:PROT:AN20PCARD -1.9

6. Repeat steps 4 and 5 for the 200pA through 2μA ranges using the calibration values summarized in Table 2-11. For each step, be sure to connect the appropriate resistance, set the DC calibrator voltage as required, and use the correct command.
7. Disconnect the calibration standard and voltage calibrator, and connect the traix cap to the INPUT jack.
8. Send the following command:

   :CAL:PROT:AZERO20U
   :CAL:PROT:AZERO200U
   :CAL:PORT:AZERO2M
   :CAL:PROT:AZERO20M

9. Connect the DC current calibrator to the INPUT jack.
10. Set the DC current calibrator output to +19.00000μA, then send the following command:

    :CAL:PROT:A20U 19E-6

11. Set the DC current calibrator output to -19.00000μA, then send the following command:

    :CAL:PROT:AN20U -19E-6

12. Repeat steps 10 and 11 for the 200μA through 20mA ranges using the calibration currents and commands summarized in Table 2-12.

Table 2-11
IEEE-488 bus amps calibration summary (20pA-2μA ranges)

Calibration voltage	Resistance[1] standard	Nominal[2] current	Calibration command
Triax cap	100GΩ	0pA	:CAL:PROT:AZERO20P
Triax cap	10GΩ	0pA	:CAL:PROT:AZERO200P
Triax cap	1GΩ	0nA	:CAL:PROT:AZERO2N
Triax cap	100MΩ	0nA	:CAL:PROT:AZERO20N
Triax cap	100MΩ	0nA	:CAL:PROT:AZERO200N
Triax cap	100MΩ	0μA	:CAL:PROT:AZERO2U
1.900000V	100GΩ	19pA	:CAL:PROT:A20PCARD 1.9
-1.900000V	100GΩ	-19pA	:CAL:PROT:AN20PCARD -1.9
1.900000V	10GΩ	190pA	:CAL:PROT:A200PCARD 1.9
-1.900000V	10GΩ	-190pA	:CAL:PROT:AN200PCARD -1.9
1.900000V	1GΩ	1.9nA	:CAL:PROT:A2NCARD 1.9
-1.900000V	1GΩ	-1.9nA	:CAL:PROT:AN2NCARD -1.9
1.900000V	100MΩ	19nA	:CAL:PROT:A20NCARD 1.9
-1.900000V	100MΩ	-19nA	:CAL:PROT:AN20NCARD -1.9
19.00000V	100MΩ	190nA	:CAL:PROT:A200NCARD 19
-19.00000V	100MΩ	-190nA	:CAL:PROT:AN200NCARD -19
190.0000V	100MΩ	1.9μA	:CAL:PROT:A2UCARD 190
-190.0000V	100MΩ	-1.9μA	:CAL:PROT:AN2UCARD -190

[1]Actual resistance standard value determined from calibration data supplied with standard.
[2]Actual calibration current : I = V/R, where is the calibration voltage, and R is the actual resistance standard value. When using the Model 5156 Electrometer Calibration Standard, the Model 6517 automatically calculates the current from the applied voltage and actual resistance value.

Table 2-12
IEEE-488 bus amps calibration summary (20μA-20mA ranges)

Calibration current	Calibration command
Triax cap	:CAL:PROT:AZERO20U
Triax cap	:CAL:PROT:AZERO200U
Triax cap	:CAL:PROT:AZERO2M
Triax cap	:CAL:PROT:AZERO20M
19.00000μA	:CAL:PROT:A20U 19E-6
19.00000μA	:CAL:PROT:AN20U -19E-6
190.0000μA	:CAL:PROT:A200U 190E-6
190.0000μA	:CAL:PROT:AN200U -190E-6
1.900000mA	:CAL:PROT:A2M 1.9E-3
1.900000mA	:CAL:PROT:AN2M -1.9E-3
19.00000mA	:CAL:PROT:A20M 19E-3
19.00000mA	:CAL:PROT:AN20M -19E-3

Step 6: Coulombs Calibration

Perform the steps below to calibrate the coulombs function over the bus. Table 2-13 summarizes the necessary steps.

1. Connect the calibration standard and DC voltage calibrator to the Model 6517 INPUT jack (see Figure 2-5). Initially, make connections to the 1nF capacitor in the standards box.
2. Set the output voltage of the DC calibrator to 0.00000V.
3. Send the following command over the bus:

   :CAL:PROT:CZEROA2N

4. Set the calibrator output voltage to +1.900000V, then send the following command over the bus:

   :CAL:PROT:C2NCARD 1.9

5. Set the calibrator output voltage to 0.000000V, then send the following command:

   :CAL:PROT:CZEROB2N

6. Set the calibrator output voltage to -1.900000V, then send:

   :CAL:PROT:CN2NCARD -1.9

7. Repeat steps 3 to 6 for the remaining coulombs calibration steps summarized in Table 2-13.

Step 7: Temperature Calibration

Follow the steps below to calibrate the Model 6517 temperature function.

1. Connect the thermocouple calibrator to the Model 6517 EXT TEMP jack (see Figure 2-6).
2. Set the thermocouple calibrator output to 0°C (0mV), then send the following command:

   :CAL:PROT:TZERO

3. Set the DC voltage calibrator output to 1232°C (50mV), then send either of the following commands:

   :CAL:PROT:T50

or,

   CAL:PROT:T1232

Table 2-13
IEEE-488 bus coulombs calibration summary

Calibration voltage	Standard[1] capacitance	Nominal[2] charge	Calibration command
0.000000V	1nF	0nC	:CAL:PROT:CZEROA2N
1.900000V	1nF	1.9nC	:CAL:PROT:C2NCARD 1.9
0.000000V	1nF	0nC	:CAL:PROT:CZEROB2N
-1.900000V	1nF	-1.9nC	:CAL:PROT:CN2NCARD -1.9
0.000000V	1nF	0nC	:CAL:PROT:CZEROA20N
19.00000V	1nF	19nC	:CAL:PROT:C20NCARD 19
0.000000V	1nF	0nC	:CAL:PROT:CZEROB20N
-19.00000V	1nF	-19nC	:CAL:PROT:CN20NCARD -19
0.000000V	100nF	0nC	:CAL:PROT:CZEROA200N
1.900000V	100nF	190nC	:CAL:PROT:C200NCARD 1.9
0.000000V	100nF	0nC	:CAL:PROT:CZEROB200N
-1.900000V	100nF	-190nC	:CAL:PROT:CN200NCARD -1.9
0.000000V	100nF	0µC	:CAL:PROT:CZEROA2U
19.00000V	100nF	1.9µC	:CAL:PROT:C2UCARD 19
0.000000V	100nF	0µC	:CAL:PROT:CZEROB2U
-19.00000V	100nF	-1.9µC	100nF :CAL:PROT:CN2UCARD -19

[1]Nominal capacitance standard shown. Refer to calibration data for actual value.
[2]Charge calculated from: Q = CV, where C is capacitance standard value, and V is the calibrator voltage. When using the Model 5156 Electrometer Calibration Standard, the Model 6517 automatically computes the charge from the applied voltage and the actual capacitance value.

Step 8: Voltage Source Calibration

Perform the steps below the calibrate the Model 6517 voltage source. Table 2- 14 summarizes these steps.

WARNING

Hazardous voltages will be present when performing the following steps. Avoid touching terminals while performing this procedure.

1. Select the DCV function and the auto-range mode on the DMM.
2. Temporarily short the ends of the DMM test leads, then enable the DMM REL mode. Leave REL enabled for the remainder of the tests.
3. Connect the DMM to the V SOURCE OUT jacks (see Figure 2-7).
4. Send the following command to the instrument:

   :CAL:PROT:VSETZ100

5. After settling, note the DMM reading, then send the actual DMM reading as a numeric parameter included with the following command:

   :CAL:PROT:VSRCZ100 <DMM_reading>

   For example, if the actual DMM reading were 0.005V, you would send the following command:

   :CAL:PROT:VSRCZ100 5E-3

6. Repeat steps 4 and 5 for each voltage source output value listed in Table 2-14. Keep in mind that each calibration point is a two-step process:

   - First send the appropriate VSET command to program the voltage source to the correct output value.
   - Note the DMM voltage reading, then include that reading as a numeric parameter with the corresponding VSRC command. Be sure to include the minus sign for negative parameters.

Table 2-14
IEEE-488 bus voltage source calibration summary

Calibration step	Calibration command*
Output 0V (100V range)	:CAL:PROT:VSETZ100
Program 0V DMM reading	:CAL:PROT:VSRCZ100 <DMM_reading>
Output +40V	:CAL:PROT:VSET40
Program +40V DMM reading	:CAL:PROT:VSRC40 <DMM_reading>
Output +100V	:CAL:PROT:VSET100
Program +100V DMM reading	:CAL:PROT:VSRC100 <DMM_reading>
Output -100V	:CAL:PROT:VSETN100
Program -100V DMM reading	:CAL:PROT:VSRCN100 <DMM_reading>
Output 0V (1000V range)	:CAL:PROT:VSETZ1000
Program 0V DMM reading	:CAL:PROT:VSRCZ1000 <DMM_reading>
Output +400V	:CAL:PROT:VSET400
Program +400V DMM reading	:CAL:PROT:VSRC400 <DMM_reading>
Output +1000V	:CAL:PROT:VSET1000
Program +1000V DMM reading	:CAL:PROT:VSRC1000 <DMM_reading>
Output -1000V	:CAL:PROT:VSETN1000
Program -1000V DMM reading	:CAL:PROT:VSRCN1000 <DMM_reading>

* <DMM_reading> parameter is actual DMM reading obtained after programming voltage source output using VSET command from previous step.

Step 9: Humidity Calibration

Perform the steps below to calibrate the Model 6517 humidity function. These steps are summarized in Table 2-15.

1. Connect the DC voltage calibrator to the rear panel HUMIDITY jack (see Figure 2-8).
2. Set the DC calibrator output to 0.00000V, then send the following command over the bus:

   :CAL:PROT:HUMZER0

3. Repeat steps 2 and 3 for 0.5V and 1V input using the calibrator voltages and commands summarized in Table 2-15.

Table 2-15
IEEE-488 bus humidity calibration summary

Calibration point	Calibrator voltage	Calibration command
0V (0% RH)	0.00000V	:CAL:PROT:HUMZERO
0.5V (50% RH)	0.50000V	:CAL:PROT:HUM05
1V (100% RH)	1.00000V	:CAL:PROT:HUM1

Step 10: Program Calibration Dates

To set the calibration date and next due date, use following commands to do so:

:CAL:PROT:DATE <yr>, <mon>, <date> (calibration date)
:CAL:PROT:NDUE <yr>, <mon>, <date> (next calibration due date)

Note that the year, month, and date must be separated by commas. The allowable range for the year is from 1994 to 2093, the month is from 1 to 12, and the date is from 1 to 31.

Step 11: Save Calibration Constants

Calibration is now complete, so you can store the calibration constants in EEPROM by sending the following command:

:CAL:PROT:SAVE

NOTE

Calibration will be temporary unless you send the SAVE command.

Step 12: Lock Out Calibration

To lock out further calibration, send the following command after completing the calibration procedure:

:CAL:PROT:LOCK

2.10 Single-point calibration

Normally, the complete comprehensive calibration procedure should be performed to ensure that the entire instrument is properly calibrated. In some instances, however, it may be desirable to calibrate only certain ranges or functions. For those cases, a single-point calibration feature is included in the Model 6517.

The following paragraphs give an overview of performing single-point calibration, both from the front panel and over the IEEE-488 bus. For details on specific procedures and test equipment connections, refer to paragraphs 2.8 and 2.9 of this section. For comprehensive information on IEEE-488 bus calibration commands, see Section 3.

Remember that calibration must first be unlocked. To unlock comprehensive calibration, press in on the CAL switch.

2.10.1 Front panel single-point calibration

Front panel single-point calibration can be performed by using the POINT-CALS selection in the CALIBRATION menu. You will then be prompted as to which function to calibrate using the following menu:

VOLTS AMPS CHARGE V-SOURCE ▶
◀ EXT-TEMP HUMIDITY ZEROCHECK

If you choose VOLTS, AMPS, or CHARGE, you can then choose whether to calibrate all ranges for that function, or just a single range. For example, the menu selections for the volts function include:

CHOOSE VOLTS RANGE
ALL 2V 20V 200V

With the ALL selection, all steps for that function will be carried out without duplicating the zero calibration step for that range. See paragraph 2.8 for details on front panel comprehensive calibration steps.

Once you have calibrated all desired functions and ranges, exit the calibration menu by pressing the EXIT key. You will then be prompted as to whether or not the new calibration points are to be saved. To make changes permanent, save calibration; however, choose not to save calibration if you wish calibration to be only temporary.

Example

Assume that you wish to calibrate the volts function. Follow the steps below to do so:

1. Turn on the Model 6517, and allow the instrument to warm up for at least one hour before performing calibration.
2. Press in on the front panel CAL switch to unlock calibration.
3. Press the MENU key. The instrument will display the following menu:

   MAIN MENU
   SAVESETUP COMMUNICATION CAL

4. Select CAL, then press ENTER. If the optional Model 5156 Calibration Standard is connected to the DIGITAL I/O port, the following prompt will be displayed:

   USE CAL OPTION CARD?
   YES NO

5. Select yes, then press ENTER.
6. The following menu will be displayed:

   PERFORM CALIBRATION
   COMPREHENSIVE POINT-CALS

7. Select POINT-CALS, then press ENTER. The Model 6517 will prompt you to select the function:

   POINT-CALS
   VOLTS AMPS CHARGE VSOURCE ▶
   ◀ EXT-TEMP HUMIDITY ZEROCHECK

8. Select VOLTS, then press ENTER. The unit will prompt you to choose the range:

   CHOOSE VOLTS RANGE
   ALL 2V 20V 200V

9. Select the desired option, then press ENTER. If you wish to calibrate all volts ranges, choose ALL; otherwise, select the range to be calibrated, then press the ENTER key.
10. Follow the prompts regarding the various calibration steps, and refer to paragraph 2.8 for additional information.
11. Repeat the above steps for other calibration points, if desired.
12. If desired, select CAL-DATES in the calibration menu, then set the calibration date and due date accordingly.
13. Press EXIT as necessary to return to normal display. If you wish calibration to be permanent, select the save option; valid calibration constants will be saved, and calibration will be locked out.

2.10.2 IEEE-488 bus single-point calibration

To perform IEEE-488 bus single-point calibration, simply connect the appropriate signal, then send the corresponding calibration commands. Keep in mind that all commands for a given range or function must be sent in order to completely calibrate that range or function. (See paragraph 2.9 for more information on commands and procedures.)

Remember that you must unlock calibration first. Also, it is strongly recommended that you perform voltage offset, bias current, and zero check calibration before calibrating a volts, amps, or coulombs range or function.

Before sending any calibration commands, you must send the ":CAL:PROT:INIT" command to initialize calibration. After calibrating the desired point(s), you must then save the new calibration constants by sending the ":CAL:PROT:SAVE" command over the bus. You can then lock out calibration by sending ":CAL:PROT:LOCK".

Example

As an example, assume that you intend to calibrate the 20V range of the volts function. The basic steps are summarized below:

1. Turn on the Model 6517 power, and allow the instrument to warm up for at least one hour before performing calibration.
2. Press the front panel CAL switch to unlock calibration.
3. Send the following command over the bus to initiate calibration:

   :CAL:PROT:INIT

4. Perform voltage offset, bias current, and zero check calibration as outlined in Step 2 of the IEEE-488 bus calibration procedure in paragraph 2.9.2.
5. Connect the DC voltage calibrator to the INPUT jack (see Figure 2-2).
6. Set the output voltage of the DC calibrator to 0.000000V, then send the following command:

   :CAL:PROT:VZERO20

7. Set the output voltage of the DC calibrator to +19.00000V, then send the following command:

   :CAL:PROT:V20 19

8. Set the output voltage of the DC calibrator to -19.00000V, then send the following command:

   :CAL:PROT:VN20 -19

9. Repeat steps 6 through 8 as desired for other calibration points.
10. If desired, send the following commands to program the calibration date and calibration due date:

    :CAL:PROT:DATE <yr>,<mon>,<date>
    :CAL:PROT:NDUE <yr>,<mon>,<date>

Here, <yr> is the year (1994-2093), <mon> is the month (1-12), and <date> can have any value between 1 and 31.

11. Send the following command to save calibration constants:

    :CAL:PROT:SAVE

12. Finally, send the following command to lock out calibration:

    :CAL:PROT:LOCK

2.11 Programming calibration dates

Normally calibration dates are programmed when the instrument is calibrated. However, you can change these dates at any time by using the basic procedure outlined below.

1. From normal display, press the MENU key, and note that the instrument displays the following:

   MAIN MENU
   SAVESETUP COMMUNICATION CAL

2. Select CAL, then press ENTER. The following options will be displayed:

   PERFORM CALIBRATION
   COMPREHENSIVE POINT-CALS ▶
   ◀ CAL-DATES OFFSET-ADJ CAL-OPT

3. Select CAL-DATES, and note that unit displays the following selections:

   CALIBRATION DATES
   VIEW DISPLAY-AT-POWERUP CHANGE

4. Choose the option based on the desired action:

   VIEW: Allows you to view the last calibration and calibration due dates.

   DISPLAY-AT-POWERUP: Allows you to select whether or not calibration dates are automatically displayed at power-up (choose YES to enable, NO to disable calibration date display at power-up).

   CHANGE: Use this option to change the last calibration date or the calibration due date. Simply follow the display prompts to change the dates as desired.

2.12 Calibration temperature difference

You can obtain information on the difference between the present Model 6517 internal temperature and the internal temperature of the instrument when it was calibrated. Front panel and bus display methods are discussed below.

2.12.1 Front panel temperature difference

To display the temperature difference on the front panel, repeatedly press the NEXT key until the temperature difference is shown on the second display.

2.12.2 IEEE-488 bus temperature difference

To obtain the temperature difference over the bus, send the following command to the instrument:

FORMat:ELEMents:DTEMperature

See the Model 6517 Operator's Manual for more information on using the FORMAT command.

3

Calibration Command Reference

3.1 Introduction

This section contains detailed information on the various Model 6517 IEEE-488 bus calibration commands. Section 2 of this manual covers detailed calibration procedures. For information on additional commands to control other instrument functions, refer to the Model 6517 User Manual.

Information in this section includes:

3.2 **Command summary:** Summarizes all commands necessary to perform comprehensive calibration.

3.3 **Miscellaneous commands:** Covers commands that initiate calibration, program calibration dates, lock out calibration, and save calibration constants.

3.4 **Meter commands:** Details those commands used to calibrate the Model 6517 meter functions (volts, amps, and coulombs).

3.5 **Voltage source commands:** Outlines those commands used to calibrate the Model 6517 voltage source.

3.6 **Temperature commands:** Discusses commands required to calibrate the temperature function.

3.7 **Humidity commands:** Covers commands used for calibrating the humidity function.

3.8 **Calibration errors:** Summarizes bus calibration error commands, and discusses how to obtain error information.

3.9 **Detecting calibration step completion:** Covers how to determine when each calibration step is completed by using the *OPC and *OPC? commands.

3.2 Command summary

Table 3-1 summarizes Model 6517 calibration commands.

Table 3-1
IEEE-488 bus calibration command summary

Command	Description
CALibration:	Calibration subsystem
PROTected:	Commands protected by CAL switch
INITiate	Required before performing ANY cal steps
VZERO2	2V range zero step
V2 <Nrf>	+2V step
VN2 <Nrf>	-2V step
VZERO20	20V range zero step
V20 <Nrf>	+20V step
VN20 <Nrf>	-20V step
VZERO200	200V range zero step
V200 <Nrf>	+200V step
VN200 <Nrf>	-200V step
AZERO20P	20pA range zero step
A20P <Nrf>	+20pA step
A20PCARD <Nrf>	+20pA step (using cal standard)
AN20P <Nrf>	-20pA step
AN20PCARD <Nrf>	-20pA step (using cal standard)
AZERO200P	200pA range zero step
A200P <Nrf>	+200pA step
A200PCARD <Nrf>	+200pA step (using cal standard)
AN200P <Nrf>	-200pA step
AN200PCARD <Nrf>	-200pA step (using cal standard)
AZERO2N	2nA range zero step
A2N <Nrf>	+2nA step
A2NCARD <Nrf>	+2nA step (using cal standard)
AN2N <Nrf>	-2nA step
AN2NCARD <Nrf>	-2nA step (using cal standard)
AZERO20N	20nA range zero step
A20N <Nrf>	+20nA step
A20NCARD <Nrf>	+20nA step (using cal standard)
AN20N <Nrf>	-20nA step
AN20NCARD <Nrf>	-20nA step (using cal standard)
AZERO200N	200nA range zero step
A200N <Nrf>	+200nA step
A200NCARD <Nrf>	+200nA step (using cal standard)
AN200N <Nrf>	-200nA step
AN200NCARD <Nrf>	-200nA step (using cal standard)
AZERO2U	2µA range zero step
A2U <Nrf>	+2µA step
A2UCARD <Nrf>	+2µA step (using cal standard)
AN2U <Nrf>	-2µA step
AN2UCARD <Nrf>	-2µA step (using cal standard)
AZERO20U	20µA range zero step
A20U <Nrf>	+20µA step
AN20U <Nrf>	-20µA step
AZERO200U	200µA range zero step
A200U <Nrf>	+200µA step
AN200U <Nrf>	-200µA step

Table 3-1
IEEE-488 bus calibration command summary (cont.)

Command	Description
CALibration:	
PROTected:	
AZERO2M	2mA range zero step
A2M <Nrf>	+2mA step
AN2M <Nrf>	-2mA step
AZERO20M	2mA range zero step
A20M <Nrf>	+20mA step
AN20M <Nrf>	-20mA step
CZEROA2N	2nC range zero check part A
C2N <Nrf>	+2nC step
C2NCARD <Nrf>	+2nC step (using cal standard)
CZEROB2N	2nC range zero check part B
CN2N <Nrf>	-2nC step
CN2NCARD <Nrf>	-2nC step (using cal standard)
CZEROA20N	20nC range zero check part A
C20N <Nrf>	+20nC step
C20NCARD <Nrf>	+20nC step (using cal standard)
CZEROB20N	20nC range zero check part B
CN20N <Nrf>	-20nC step
CN20NCARD <Nrf>	-20nC step (using cal standard)
CZEROA200N	200nC range zero check part A
C200N <Nrf>	+200nC step
C200NCARD <Nrf>	+200nC step (using cal standard)
CZEROB200N	200nC range zero check part B
CN200N <Nrf>	-200nC step
CN200NCARD <Nrf>	-200nC step (using cal standard)
CZEROA2U	2µC range zero check part A
C2U <Nrf>	+2µC step
C2UCARD <Nrf>	+2µC step (using cal standard)
CZEROB2U	2µC range zero check part B
CN2U <Nrf>	-2µC step
CN2UCARD <Nrf>	-2µC step (using cal standard)
TZERO	0mV (0°C) temperature step
T50	+50mV (1232°C) temperature step
T1232	+50mV (1232°C) temperature step (alternate)
VSETZ100	Set voltage source to 0V for next command
VSRCZ100 <Nrf>	Voltage source 100V range 0V cal
VSETZ1000	Set voltage source to 0V for next command
VSRCZ1000 <Nrf>	Voltage source 1000V range 0V cal
VSET40	Set voltage source to +40V
VSRC40 <Nrf>	Voltage source +40 V cal
VSET100	Set voltage source to +100V
VSRC100 <Nrf>	Voltage source +100V cal
VSETN100	Set voltage source to -100V
VSRCN100 <Nrf>	Voltage source -100V cal
VSET400	Set voltage source to +400V
VSRC400 <Nrf>	Voltage source +400V cal

Table 3-1
IEEE-488 bus calibration command summary (cont.)

Command	Description
CALibration:	
PROTected:	
VSET1000	Set voltage source to +1000V
VSRC1000 <Nrf>	Voltage source +1000 V cal
VSETN1000	Set voltage source to -1000 V
VSRCN1000 <Nrf>	Voltage source -1000 V cal
HUMZERO	Humidity input 0 V step
HUM05	Humidity input 0.5 V step
HUM1	Humidity input 1.0 V step
LOCK	Re-locks the calibration paths. (A new CAL switch press and CAL:PROT:INIT command are required before any cal commands can be performed again.)
SAVE	Saves the cal constants in NVRAM
DATE <yyyy, mm, dd>	Calibration date yyyy = year (1994-2093), mm = month (1-12), dd =date (1-31)
DATE?	Request calibration date
NDUE <yyyy, mm, dd>	Calibration due date
NDUE?	Request calibration due date
SWITch?	Request CAL switch state (0 = unlocked, 1 = locked)
CALTEMP	Acquire the calibration temperature.
CALibration:	
UNPRotected:	These commands not protected by CAL switch
VOFFset	Perform offset voltage calibration
IOFFset	Perform bias current calibration
EERR?	Request cal execution error status
VERR?	Request voltage function cal errors
AERR?	Request amps function cal errors
CERR?	Request coulombs function cal errors
TERR?	Request temperature function cal errors
FERR?	Request factory calibration errors
OPTion?	Request option presence status

NOTE: Upper-case letters indicate short form of each command. For example, instead of sending ":CALibration:PROTected:INITiate", you can send ":CAL:PROT:INIT".

3.3 Miscellaneous commands

Miscellaneous commands are those commands that have such functions as initiating calibration, saving calibration constants, locking out calibration, and programming date parameters.

3.3.1 :INIT (:CALibration:PROTected:INITiate)

Purpose To initiate calibration.

Format
```
:cal:prot:init
```

Parameter None

Description The :INIT command enables Model 6517 calibration when performing these procedures over the bus. In general, this command must be sent to the unit before sending any other comprehensive calibration command.

Programming Note The :INIT command should be sent only once before performing either complete or single-point calibration. Do not send :INIT before each calibration step.

Example
```
:CAL:PROT:INIT          Initiate calibration
```

3.3.2 :LOCK (:CALibration:PROTected:LOCK)

Purpose To lock out calibration.

Format
```
:cal:prot:lock
```

Parameter None

Description The :LOCK command allows you to lock out comprehensive calibration after completing those procedures. Thus, :LOCK performs the opposite of pressing in on the front panel CAL switch.

Programming Note To unlock comprehensive calibration, press in on the CAL switch with the power turned on.

Example
```
:CAL:PROT:LOCK          Lock out calibration
```

3.3.3 :SWITch? (:CALibration:PROTected:SWITch?)

Purpose To read calibration lock status.

Format
```
:cal:prot:swit?
```

Response
0 Calibration locked
1 Calibration unlocked.

Description The :SWITch? query requests status from the Model 6517 on calibration locked/unlocked state. Calibration must be unlocked by pressing in on the CAL switch while power is turned on before calibration can be performed.

Example
:CAL:PROT:SWIT? Request CAL switch status.

3.3.4 :SAVE (:CALibration:PROTected:SAVE)

Purpose To save calibration constants in EEPROM after the calibration procedure.

Format
```
:cal:prot:save
```

Parameter None

Description The :SAVE command stores internally calculated calibration constants derived during comprehensive calibration in EEPROM. EEPROM is non-volatile memory, and calibration constants will be retained indefinitely once saved. Generally, :SAVE is sent after all other calibration steps (except for :LOCK).

Programming Note Calibration will be only temporary unless the :SAVE command is sent to permanently store calibration constants.

Example
:CAL:PROT:SAVE Save calibration constants

3.3.5 :DATE (:CALibration:PROTected:DATE)

Purpose To send the calibration date to the instrument.

Format
```
:cal:prot:date <yr>, <mon>, <day>
```

Parameters <yr> = year (yyyy, 1994 to 2093)
<mon> = month (mm, 1 to 12)
<day> = day of month (dd, 1 to 31)

Query Format
```
:cal:prot:date?
```

Response <yr> , <mon> , <day>

Description The :DATE command allows you to store the calibration date in instrument memory for future reference. You can read back the date from the instrument over the bus by using the :DATE? query, or by using the CAL-DATES selection in the front panel CAL menu.

Programming Note The year, month, and day parameters must be delimited by commas.

Examples

:CAL:PROT:DATE 1994,12,16	Send cal date (12/16/94).
:CAL:PROT:DATE?	Request date.

3.3.6 :NDUE (:CALibration:PROTected:NDUE)

Purpose To send the next calibration due date to the instrument.

Format
```
:cal:prot:ndue <yr>, <mon>, <day>
```

Parameters <yr> = year (yyyy, 1994 to 2093)
<mon> = month (mm, 1 to 12)
<day> = day of month (dd, 1 to 31)

Query Format
```
:cal:prot:ndue?
```

Response <yr>, <mon>, <day>

Description The :NDUE command allows you to store the date when calibration is next due in instrument memory. You can read back the next due date from the instrument over the bus by using the :NDUE? query, or by using the CAL-DATES selection in the front panel CAL menu.

Programming Note The next due date parameters must be delimited by commas.

Examples

:CAL:PROT:NDUE 1995,12,16	Send due date (12/16/95).
:CAL:PROT:NDUE?	Request due date.

3.3.7 :DATA? (:CALibration:PROTected:DATA?)

Purpose To download calibration constants from the Model 6517.

Format
```
:cal:prot:data?
```

Response <Cal_1>,<Cal_2>,...<Cal_n>

Description The :DATA? query allows you to request calibration constants stored in EEROM from the instrument. This command can be used to compare present constants with those from a previous calibration procedure to verify that calibration was performed properly. The returned values are floating-point ASCII numbers delimited by commas (,).

Programming Note See Appendix B for summary of constants returned by the :DATA? query.

Example :CAL:PROT:DATA? Request calibration constants.

3.3.8 :OPT? (:CALibration:UNPRotected:OPTion?)

Purpose To detect the presence of the optional calibration standard.

Format
```
:cal:prot:opt?
```

Response

0	Cal standard not present
5156-CALOPT	Cal standard present

Description The :OPT? query allows you to determine whether or not the optional Model 5156 Electrometer Calibration Standard is connected to the Model 6517 DIGITAL I/O port. The unit will respond with the appropriate string depending on whether or not the calibration standard is connected and operational.

Example :CAL:PROT:OPT? Request option presence status.

3.3.9 :CALTEMP (:CALibration:PROTected:CALTEMP)

Purpose To acquire the calibration temperature.

Format
```
:cal:prot:caltemp
```

Response None

Description The :CALTEMP command acquires the temperature at which the Model 6517 was calibrated. The command should be sent without the thermocouple connected to the Model 6517 and may be issued at any point during calibration. When calibrating from the front panel, the calibration temperature will be acquired when the calibration dates and constants are saved. (This command is supported with main firmware revision level B07 or later.)

Example :CAL:PROT:CALTEMP Acquire calibration temperature.

3.4 Meter commands

Meter commands include those necessary to null offsets and calibrate the volts, amps, and coulombs measurement functions.

3.4.1 Offset commands

:VOFF **(:CALibration:UNPRotected:VOFFset)**

Purpose To null voltage offsets.

Format

```
:cal:unpr:voff
```

Parameter None

Description The :VOFF command performs voltage offset calibration and is normally used as part of the calibration procedure. :VOFF can also be sent during normal operation to null voltage offsets at any time.

Programming Note

1. :VOFF is not protected by the CAL switch.
2. When :VOFF is used as part of the normal calibration procedure, voltage offset compensation constants are permanently saved. When :VOFF is sent during normal operation (with calibration locked), voltage offset compensation is only temporary.

Example :CAL:PROT:VOFF Perform voltage offset calibration

:IOFF **(:CALibration:UNPRotected:IOFFset)**

Purpose To null bias current.

Format

```
:cal:unpr:ioff
```

Parameter None

Description The :IOFF command performs bias current calibration and is normally used as part of the calibration procedure. :IOFF can also be sent during normal operation to null bias current at any time.

Programming Note

1. :IOFF is not protected by the CAL switch.
2. When :IOFF is used as part of the normal calibration procedure, bias current compensation constants are permanently saved. When :IOFF is sent during normal operation (with calibration locked), bias current compensation is only temporary.

Example :CAL:PROT:IOFF Perform bias current calibration

3.4.2 Volts function calibration commands

Purpose To calibrate voltage function ranges.

Format See Table 3-2.

Parameter See Table 3-2.

Table 3-2
Volts function calibration commands and parameters

Range	Command format*	<Cal_voltage> parameter limits (V)
2V	:cal:prot:vzero2 :cal:prot:v2 <Cal_voltage> :cal:prot:vn2 <Cal_voltage>	None 0.95 to 2.05 -0.95 to -2.05
20V	:cal:prot:vzero20 :cal:prot:v20 <Cal_voltage> :cal:prot:vn20 <Cal_voltage>	None 9.5 to 20.5 -9.5 to -20.5
200V	:cal:prot:vzero200 :cal:prot:v200 <Cal_voltage> :cal:prot:vn200 <Cal_voltage>	None 95 to 205 -95 to -205

* Command short form shown.

Description The :V commands calibrate the three volts function ranges: 2V, 20V, and 200V. Each range requires three commands, corresponding to zero, positive full range, and negative full range. For example, :VZERO2 calibrates 2V range zero, while :V2 and :VN2 calibrate positive 2V full range and negative 2V full-range values respectively. Normally, 95% of full-range values should be used. For example, +19V and -19V should be used to calibrate the 20V range.

Programming Note All three commands for a given range must be sent in order to properly calibrate that range.

Examples

:CAL:PROT:VZERO20	Cal 20V range zero.
:CAL:PROT:V20 19	Cal 20V positive 95% of full range.
:CAL:PROT:VN20 -19	Cal 20V negative 95% of full range.

3.4.3 Amps calibration commands

Purpose To calibrate amps function ranges.

Format See Tables 3-3 and 3-4.

Parameter See Tables 3-3 and 3-4.

Table 3-3
Amps function calibration commands and parameters (all ranges, without calibration standard

Range	Command format*	<Cal_current> parameter limits (A)
20pA	:cal:prot:azero20p :cal:prot:a20p <Cal_current> :cal:prot:an20p <Cal_current>	None 9.5E-12 to 20.5E-12 -9.5E-12 to -20.5E-12
200pA	:cal:prot:azero200p :cal:prot:a200p <Cal_current> :cal:prot:an200p <Cal_current>	None 95E-12 to 205E-12 -95E-12 to -205E-12
2nA	:cal:prot:azero2n :cal:prot:a2n <Cal_current> :cal:prot:an2n <Cal_current>	None 0.95E-9 to 2.05E-9 -0.95E-9 to -2.05E-9
20nA	:cal:prot:azero20n :cal:prot:a20n <Cal_current> :cal:prot:an20n <Cal_current>	None 9.5E-9 to 20.5E-9 -9.5E-9 to -20.5E-9
200nA	:cal:prot:azero200n :cal:prot:a200n <Cal_current> :cal:prot:an200n <Cal_current>	None 95E-9 to 205E-9 -95E-9 to -205E-9
2µA	:cal:prot:azero2u :cal:prot:a2u <Cal_current> :cal:prot:an2u <Cal_current>	None 0.95E-6 to 2.05E-6 -0.95E-6 to -2.05E-6
20µA	:cal:prot:azero20u :cal:prot:a20u <Cal_current> :cal:prot:an20u <Cal_current>	None 9.5E-6 to 20.5E-6 -9.5E-6 to -20.5E-6
200µA	:cal:prot:azero200u :cal:prot:a200u <Cal_current> :cal:prot:an200u <Cal_current>	None 95E-6 to 205E-6 -95E-6 to -205E-6
2mA	:cal:prot:azero2m :cal:prot:a2m <Cal_current> :cal:prot:an2m <Cal_current>	None 0.95E-3 to 2.05E-3 -0.95E-3 to -2.05E-3
20mA	:cal:prot:azero20m :cal:prot:a20m <Cal_current> :cal:prot:an20m <Cal_current>	None 9.5E-3 to 20.5E-3 -9.5E-3 to -20.5E-3

* Command short form shown.

Table 3-4
Amps function calibration commands and parameters (20pA-2μA ranges, using calibration standard

Range	Command format*	<Cal_voltage> parameter limits (V)
20pA	:cal:prot:azero20p :cal:prot:a20pcard <Cal_voltage> :cal:prot:an20pcard <Cal_voltage>	None 0.95 to 2.05 -0.95 to -2.05
200pA	:cal:prot:azero200p :cal:prot:a200pcard <Cal_voltage> :cal:prot:an200pcard <Cal_voltage>	None 0.95 to 2.05 -0.95 to -2.05
2nA	:cal:prot:azero2n :cal:prot:a2ncard <Cal_voltage> :cal:prot:an2ncard <Cal_voltage>	None 0.95 to 2.05 -0.95 to -2.05
20nA	:cal:prot:azero20n :cal:prot:a20ncard <Cal_voltage> :cal:prot:an20ncard <Cal_voltage>	None 0.95 to 2.05 -0.95 to -2.05
200nA	:cal:prot:azero200n :cal:prot:a200ncard <Cal_voltage> :cal:prot:an200ncard <Cal_voltage>	None 9.5 to 2.05 -9.5 to -2.05
2μA	:cal:prot:azero2u :cal:prot:a2ucard <Cal_voltage> :cal:prot:an2ucard <Cal_voltage>	None 95 to 205 -95 to -205

NOTE: Model 5156 Electrometer Calibration Standard and DC voltage calibrator are required to use these commands.

Description

The :A commands calibrate the amps function ranges using a suitable current source. Each range requires three commands, corresponding to zero, positive full range, and negative full range. For example, :AZERO2N calibrates 20nA range zero, while :A20N and :AN20N calibrate positive 20nA full range and negative 20nA full range values respectively. Commands using a current source to calibrate all ranges are summarized in Table 3-3. Normally 95% of full-range values should be used. For example, +19mA and -19mA should be used to calibrate the 20mA range.

The :A<range>CARD commands calibrate the 20pA to 2μA ranges using the optional Model 5156 Electrometer Calibration Standard and a DC voltage calibrator. Commands for use with the calibration unit and DC voltage calibrator are listed in Table 3-4.

Programming Note

All three commands for a given range must be used in order properly calibrate that range.

Examples

:CAL:PROT:AZERO20P	Cal 20pA range zero
:CAL:PROT:A20P 19E-12	Cal 20pA positive 95% of full range
:CAL:PROT:AN20P -19E-12	Cal 20pA negative 95% of full range
:CAL:PROT:A20PCARD 1.9	Cal 20pA range with cal standard
:CAL:PROT:AN20PCARD -1.9	Cal 20pA range with cal standard

3.4.4 Coulombs calibration commands

Purpose To calibrate coulombs function ranges.

Format See Tables 3-5 and 3-6.

Parameter See Tables 3-5 and 3-6.

Table 3-5
Coulombs function calibration commands and parameters (without calibration standard)

Range	Command format*	<Cal_charge> parameter limits (Q)
2nC	:cal:prot:czeroa2n :cal:prot:c2n <Cal_charge> :cal:prot:czerob2n :cal:prot:cn2n <Cal_charge>	None 0.95E-9 to 2.05E-9 None -0.95E-9 to -2.05E-9
20nC	:cal:prot:czeroa20n :cal:prot:c20n <Cal_charge > :cal:prot:czerob20n :cal:prot:cn20n <Cal_charge>	None 9.5E-9 to 20.5E-9 None -9.5E-9 to -20.5E-9
200nC	:cal:prot:czeroa200n :cal:prot:c200n <Cal_charge> :cal:prot:czerob200n :cal:prot:cn200n <Cal_charge>	None 95E-9 to 205E-9 None -95E-9 to -205E-9
2µC	:cal:prot:czeroa2u :cal:prot:c2u <Cal_charge> :cal:prot:czerob2u :cal:prot:cn2u <Cal_charge>	None 0.95E-6 to 2.05E-6 None -0.95E-6 to -2.05E-6

*Command short form shown.

Table 3-6
Coulombs function calibration commands and parameters (using calibration standard)

Range	Command format*	<Cal_voltage> parameter limits (V)
2nC	:cal:prot:czeroa2n	None
	:cal:prot:c2ncard <Cal_voltage>	0.95 to 2.05
	:cal:prot:czerob2n	None
	:cal:prot:cn2ncard <Cal_voltage>	-0.95 to -2.05
20nC	:cal:prot:czeroa20n	None
	:cal:prot:c20ncard <Cal_voltage>	9.5 to 20.5
	:cal:prot:czerob20n	None
	:cal:prot:cn20ncard <Cal_voltage>	-9.5 to -20.5
200nC	:cal:prot:czeroa200n	None
	:cal:prot:c200ncard <Cal_voltage>	95 to 205
	:cal:prot:czerob200n	None
	:cal:prot:cn200ncard <Cal_voltage>	-95 to -205
2µC	:cal:prot:czeroa2u	None
	:cal:prot:c2ucard <Cal_voltage>	9.5 to 20.5
	:cal:prot:czerob2u	None
	:cal:prot:cn2ucard <Cal_voltage>	-9.5 to -20.5

NOTE: Model 5156 Electrometer Calibration Standard and DC voltage calibrator are required to use these commands.

Description

The :C commands calibrate the coulombs function ranges using a suitable charge source. Each range requires four commands, corresponding to zero A, positive full range, zero B, and negative full range. For example, :CZEROA2N and :CZEROB2N calibrate 20nC range zeroes, while :C20N and :CN20N calibrate positive 20nC full range and negative 20nC full-range values respectively. Normally, 95% of full-range values are used (for example, 19nC). Commands using a charge source to calibrate all ranges are summarized in Table 3-5.

The :C<range>CARD commands calibrate the coulombs ranges using the optional Model 5156 Electrometer Calibration Standard and a DC voltage calibrator. Commands for use with the calibration standard and DC voltage calibrator are listed in Table 3-6.

Programming Notes

1. All four commands for a given range must be used in order properly calibrate that range.
2. Appropriate zero command must be sent before full-scale command. (A command before positive full-scale command; B command before negative full-scale command.)

Examples

:CAL:PROT:CZEROA200N	Cal 200nA range zero A.
:CAL:PROT:C200N 190E-9	Cal 200nA positive 95% of full range.
:CAL:PROT:CZEROB200N	Cal 200nA range zero B.
:CAL:PROT:CN200N -190E-9	Cal 200nA negative 95% of full range.
:CAL:PROT:C200NCARD 190	Cal 200nA range with cal standard.
:CAL:PROT:CN200NCARD -190	Cal 200nA range with cal standard.

3.5 Voltage source calibration commands

Purpose To calibrate the Model 6517 voltage source.

Format See Table 3-7.

Parameter See Table 3-7.

Description The :V commands calibrate the Model 6517 voltage source. Each calibration point uses two commands. First, the :VSET command is used to program the voltage source for a specific output voltage. An accurate voltmeter is then used to measure the actual output voltage, and that value is then sent back to the Model 6517 with the :VRC command to compensate for any discrepancies between the programmed source value and actual output voltage.

Programming Notes

1. All commands for a given range (100V or 1000V) should be sent to properly calibrate that range.
2. The appropriate VSET must be sent before the corresponding VSRC command.

Examples

:cal:prot:vset100	Set output to 100V.
:cal:prot:vsrc 100.5	Program DMM reading.

Table 3-7
Voltage source calibration commands

Command format*	<DMM Reading> parameter range
:cal:prot:vsetz100	None
:cal:prot:vsrcz100 <DMM_reading>	-1V to +1V
:cal:prot:vsetz1000	None
:cal:prot:vsrcz1000 <DMM_reading>	-1V to +1V
:cal:prot:vset40	None
:cal:prot:vsrc40 <DMM_reading>	35V to 45V
:cal:prot:vset100	None
:cal:prot:vsrc100 <DMM_reading>	95V to 105V
:cal:prot:vsetn100	None
:cal:prot:vsrcn100 <DMM_reading>	-95V to -105V
:cal:prot:vset400	None
:cal:prot:vsrc400 <DMM_reading>	395V to 405V
:cal:prot:vset1000	None
:cal:prot:vsrc1000 <DMM_reading>	995V to 1005V
:cal:prot:vsetn1000	None
:cal:prot:vsrcn1000 <DMM_reading>	-995V to -1005V

*Command short form shown.

3.6 Temperature calibration commands

Purpose To calibrate the temperature function.

Format

`:cal:prot:tzero`	0mV (0°C) cal point
`:cal:prot:t50`	50mV (1232°C) cal point
`:cal:prot:t1232`	1232°C (50mV) cal point (alternate)

Parameter None

Description The :T commands calibrate the Model 6517 temperature function. The only two temperature calibration points correspond to 0mV input and 50mV input respectively. A suitable reference junction compensated type K thermocouple calibrator is required for calibration.

Programming Note The :T50 and :T1232 commands perform the same function and may be used interchangeably.

Example

:CAL:PROT:TZERO	Cal 0mV temperature point.

3.7 Humidity calibration commands

Purpose To calibrate the humidity function.

Format

`:cal:prot:humzero`	0V cal point
`:cal:prot:hum05`	0.5V cal point
`:cal:prot:hum1`	1V cal point

Parameter None

Description The :HUM commands calibrate the Model 6517 humidity function. Three calibration points are required: 0V, 0.5V, and 1V, which correspond to 0%, 50%, and 100% relative humidity respectively.

Example

:CAL:PROT:HUM05	Cal 50% humidity point.

3.8 Calibration errors

3.8.1 Error query commands

Purpose To request calibration errors over the bus.

Format

`:cal:prot:eerr?`	Request cal execution error status
`:cal:prot:verr?`	Request voltage function cal errors
`:cal:prot:aerr?`	Request current function cal errors
`:cal:prot:cerr?`	Request charge function cal errors
`:cal:prot:terr?`	Request temperature function cal errors
`:cal:prot:herr?`	Request humidity function cal errors
`:cal:prot:serr?`	Request voltage source cal errors
`:cal:prot:ferr?`	Request factory cal errors

Parameter None

Description The calibration error queries allow you to access the various calibration error messages that might be generated during calibration. A separate query is provided for each function or category. For example, the :cal:prot:verr? query is used to request only those errors that occur while calibrating the voltage function.

Programming Note See Appendix B for a complete listing of calibration error messages.

Examples

:CAL:PROT:AERR?	Request amps cal errors.
:CAL:PROT:SERR?	Request voltage source cal errors.

3.8.2 Detecting calibration errors

If an error occurs during any calibration step, the Model 6517 will generate one of the error messages summarized above. Several methods to detect calibration errors are discussed below.

Error queue

As with other Model 6517 errors, any calibration errors will be reported in the bus error queue. You can read this queue by using the appropriate error query (see paragraph 3.8.1 above). The Model 6517 will respond with the appropriate error message, as summarized in Appendix B.

Status byte EAV (Error Available) bit

Whenever an error is available in the error queue, the EAV (Error Available) bit (bit 2) of the status byte will be set. Use the *STB? query or serial polling to obtain the status byte, then test bit 2 to see if it is set. If the EAV bit is set, an error has occurred, and you can use the appropriate error query to read the error and at the same time clear the EAV bit in the status byte. Use :SYST;ERR? for appropriate detailed error queue message.

Generating an SRQ on error

To program the instrument to generate an SRQ when an error occurs, send the following command: *SRE 4. This command will enable SRQ when the EAV bit is set. You can then read the status byte and error queue as outlined above to check for errors and to determine the exact nature of the error.

3.9 Detecting calibration step completion

When sending calibration commands over the IEEE-488 bus, you must wait until the instrument completes the current operation before sending a command. You can use either *OPC? or *OPC to help determine when each calibration step is completed.

3.9.1 Using the *OPC? query

With the *OPC? (operation complete) query, the instrument will place an ASCII 1 in the output queue when it has completed each step. To determine when the OPC response is ready, do the following:

1. Repeatedly test the MAV (Message Available) bit (bit 4) in the status byte and wait until it is set. (You can request the status byte by using the *STB? query or serial polling.)
2. When MAV is set, a message is available in the output queue, and you can read the output queue and test for an ASCII 1.
3. After reading the output queue, repeatedly test MAV again until it clears. At this point, the calibration step is completed.

3.9.2 Using the *OPC command

The *OPC (operation complete) command can also be used to detect the completion of each calibration step. In order to use *OPC to detect the end of each calibration step, you must do the following:

1. Enable operation complete by sending *ESE 1. The command sets the OPC (operation complete bit) in the standard event enable register, allowing operation complete status from the standard event status register to set the ESB (event summary bit) in the status byte when operation complete is detected.
2. Send the *OPC command immediately following each calibration command. For example:

   ```
   :CAL:PROT:VZERO2;*OPC
   ```

   Note that you must include the semicolon (;) to separate the two commands, and that the *OPC command must appear on the same line as the command.
3. After sending a calibration command, repeatedly test the ESB (Event Summary) bit (bit 5) in the status byte until it is set. (Use either the *STB? query or serial polling to request the status byte.)
4. Once operation complete has been detected, clear OPC status using one of two methods: (1) Use the *ESR? query, then read the response to clear the standard event status register, or (2) Send the *CLS command to clear the status registers. Note that sending *CLS will also clear the error queue and operation complete status.

3.9.3 Generating an SRQ on calibration complete

An SRQ (service request) can be used to detect operation complete instead of repeatedly polling the Model 6517. To use this method, send both *ESE 1 and *SRE 32 to the instrument, then include the *OPC command at the end of each calibration command line, as covered in paragraph 3.9.2 above. Clear the SRQ by querying the ESR (using the *ESR? query) to clear OPC status, then request the status byte with serial polling or the *STB? query.

Refer to your controller's documentation for information on detecting and servicing SRQs.

A

Specifications

MODEL 6517 SPECIFICATIONS

VOLTS

RANGE	5½ DIGIT RESOLUTION	ACCURACY (1 Yr.)[1] 18°– 28°C ±(%rdg + counts)	TEMPERATURE COEFFICIENT 0°– 18°C & 28°– 50°C ±(%rdg + counts)/°C
2 V	10 µV	0.025 + 4	0.003 + 2
20 V	100 µV	0.025 + 3	0.002 + 1
200 V	1 mV	0.06 + 3	0.002 + 1

Note: [1]When properly zeroed, 5½ digit, 1 PLC (power line cycle), median filter on, digital filter =10 readings.

NMRR: 60dB on 2V, 20V, >55dB on 200V, at 50Hz or 60Hz ±0.1%.

CMRR: >120dB at DC, 50Hz or 60Hz.

INPUT IMPEDANCE: >200TΩ in parallel with 20pF, < 2pF guarded (10MΩ with zero check on).

SMALL SIGNAL BANDWIDTH AT PREAMP OUTPUT: Typically 100kHz (–3db).

AMPS

RANGE	5½ DIGIT RESOLUTION	ACCURACY (1 Yr.)[1] 18°– 28°C ±(%rdg + counts)	TEMPERATURE COEFFICIENT 0°–18°C & 28°–50°C ±(%rdg + counts)/°C
20 pA	100 aA[2]	1 + 30	0.1 + 5
200 pA	1 fA[2]	1 + 5	0.1 + 1
2 nA	10 fA	0.2 + 30	0.1 + 2
20 nA	100 fA	0.2 + 5	0.03 + 1
200 nA	1 pA	0.2 + 5	0.03 + 1
2 µA	10 pA	0.1 + 10	0.005 + 2
20 µA	100 pA	0.1 + 5	0.005 + 1
200 µA	1 nA	0.1 + 5	0.005 + 1
2 mA	10 nA	0.1 + 10	0.008 + 2
20 mA	100 nA	0.1 + 5	0.008 + 1

Note: [1]When properly zeroed, 5½ digit, 1 PLC (power line cycle), median filter on, digital filter =10 readings.

[2]aA $=10^{-18}$A, fA$=10^{-15}$A.

INPUT BIAS CURRENT: <3fA at TCAL. Temperature coefficient = 0.5fA/°C.

INPUT BIAS CURRENT NOISE: <750aA p-p (capped input), 0.1Hz to 10Hz bandwidth, damping on. Digital filter = 40 readings.

INPUT VOLTAGE BURDEN at TCAL ± 1°C:

<20µV on 20pA, 2nA, 20nA, 2µA, 20µA ranges.

<100µV on 200pA, 200nA, 200µA ranges.

<2mV on 2mA range.

<4mV on 20mA range.

TEMPERATURE COEFFICIENT OF INPUT VOLTAGE BURDEN:

<10µV/°C on pA, nA, µA ranges.

PREAMP SETTLING TIME (to 10% of final value): 2.5s typical on pA ranges, damping off, 4s typical on pA ranges damping on, 9ms on nA ranges, 1ms on µA and mA ranges.

NMRR: >95dB on pA, 60dB on nA, µA, and mA ranges at 50Hz or 60Hz ±0.1%.

COULOMBS

RANGE	5½ DIGIT RESOLUTION	ACCURACY (1 Yr.)[1,2] 18°– 28°C ±(%rdg + counts)	TEMPERATURE COEFFICIENT 0°– 18°C & 28°– 50°C ±(%rdg + counts)/°C
2 nC	10 fC	0.4 + 5	0.04 + 3
20 nC	100 fC	0.4 + 5	0.04 + 1
200 nC	1 pC	0.4 + 5	0.04 + 1
2 µC	10 pC	0.4 + 5	0.04 + 1

Note: [1]Charge acquisition time must be <1000s, derate 1% for each additional 10,000s.

[2]When properly zeroed, 5½ digit, 1 PLC (power line cycle), median filter on, digital filter =10 readings.

INPUT BIAS CURRENT: <4fA at TCAL. Temperature coefficient = 0.5fA/°C.

OHMS

RANGE	5½ DIGIT RESOLUTION	ACCURACY[1] (10-100% Range) 18°-28°C (1 Yr.) ±(% rdg + cts)	TEMPERATURE COEFFICIENT (10-100% Range) 0°-18°C & 28°-50°C ±(% rdg + cts)	TEST VOLTS	AMPS RANGE
2 MΩ	10 Ω	0.125 + 1	0.01 + 1	40 V	200 µA
20 MΩ	100 Ω	0.125 + 1	0.01 + 1	40 V	20 µA
200 MΩ	1 kΩ	0.15 + 1	0.015 + 1	40 V	2 µA
2 GΩ	10 kΩ	0.225 + 1	0.035 + 1	40 V	200 nA
20 GΩ	100 kΩ	0.225 + 1	0.035 + 1	40 V	20 nA
200 GΩ	1 MΩ	0.35 + 1	0.110 + 1	40 V	2 nA
2 TΩ	10 MΩ	0.35 + 1	0.110 + 1	400 V	2 nA
20 TΩ	100 MΩ	1.025 + 1	0.105 + 1	400 V	200 pA
200 TΩ	1 GΩ	1.15 + 1	0.125 + 1	400 V	20 pA

Note: [1]Specifications are for auto V-source ohms, when properly zeroed 5½ digit, 1 PLC, median filter on, digital filter = 10 readings. If user selectable voltage is required, use manual mode. Manual mode displays resistance (up to 10^{18}Ω) calculated from measured current. Accuracy is equal to accuracy of V-source plus accuracy of selected Amps range.

PREAMP SETTLING TIME: Add voltage source settling time to preamp settling time in Amps specification.

VOLTAGE SOURCE

RANGE	STEP SIZE	ACCURACY (1 Yr.) 18°– 28°C ±(% setting+offset)	TEMPERATURE COEFFICIENT 0°– 18°C & 28°– 50°C ±(% setting+offset)/°C
100 V	5 mV	0.15 + 10 mV	0.005 + 1 mV
1000 V	50 mV	0.15 + 100 mV	0.005 + 10 mV

MAXIMUM OUTPUT CURRENT:

±10mA; active current limit at <11.5mA for 100V range.

±1mA; active current limit at <1.15mA for 1000V range.

SETTLING TIME:

<8ms to rated accuracy for 100V range.

<50ms to rated accuracy for 1000V range.

NOISE:

<150µV p-p from 0.1Hz to 10Hz for 100V range.

<1.5mV p-p from 0.1Hz to 10Hz for 1000V range.

TEMPERATURE (THERMOCOUPLE)

THERMOCOUPLE TYPE	RANGE	ACCURACY (1 Yr.)[1] 18°– 28°C ±(% rdg + °C)
K	–190°C to 1350°C	± (0.27% ± 1.5°C)

Note: [1]Excluding probe errors, TCAL ± 5°C, 1 PLC integration time.

HUMIDITY

RANGE	ACCURACY (1 Yr.)[1] 18°– 28°C ±(% rdg + % RH)
0 - 100%	± (0.3% +0.5)

Note: [1]Humidity probe accuracy must be added. This is ± 3% RH, for Model 6517-RH, up to 65°C probe environment, not to exceed 85°C.

IEEE-488 BUS IMPLEMENTATION

MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.

IMPLEMENTATION: SCPI (IEEE-488.2, SCPI-1994.0); DDC (IEEE-488.1).

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE FUNCTIONS: SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

PROGRAMMABLE PARAMETERS: Function, Range, Zero Check, Zero Suppress, EOI (DDC mode only), Trigger, Terminator (DDC mode only), 100-Reading Storage (DDC mode), 15706 Max. Reading Storage (SCPI mode), Calibration (SCPI mode only), V-Source Output, Display Format, SRQ, Status (including V-Source I-Limit), Output Format, Guard.

ADDRESS MODES: TALK ONLY and ADDRESSABLE.

TRIGGER TO READING DONE: 150ms typical, with external trigger.

RS-232 IMPLEMENTATION:

Supports: SCPI 1994.0.

Baud Rates: 300, 600, 1200, 2400, 4800, 9600, 19.2k.

Protocols: Xon/Xoff, 7 or 8 bit ASCII, parity-odd/even/none.

Connector: DB-9 TXD/RXD/GND.

GENERAL

DISPLAY: 6½-digit vacuum fluorescent multiline.

OVERRANGE INDICATION: Display reads "OVERFLOW".

RANGING: Automatic or manual.

CONVERSION TIME: Selectable 0.01 PLC to 10 PLC.

PROGRAMS: Provide front panel access to IEEE address, choice of engineering units or scientific notation, and digital calibration.

MAXIMUM INPUT: 250V peak, DC to 60Hz sine wave; 10s per minute maximum on mA ranges.

MAXIMUM COMMON MODE VOLTAGE (DC to 60Hz sine wave): Electrometer, 500V peak; V Source, 750V peak.

ISOLATION (Meter COMMON to chassis): Typically $10^{10}\Omega$ in parallel with 500pF.

INPUT CONNECTOR: Three lug triaxial on rear panel.

2V ANALOG OUTPUT: 2V for full range input. Inverting in Volts mode. Output impedance 10kΩ.

PREAMP OUTPUT: Provides a guard output for Volts measurements. Can be used as an inverting output or with external feedback in Amps and Coulombs modes.

EXTERNAL TRIGGER: TTL compatible External Trigger and Electrometer Complete.

GUARD: Switchable voltage guard available.

DIGITAL I/O AND TRIGGER LINE: Available, see manual for usage.

EMI/RFI: Meets VDE-0871 and FCC Class B limits.

TEST SEQUENCES: Device-Characterization (Diode, Capacitor, Cable, Resistor), Resistivity, Surface-Insulation-Resistance, Sweep.

READING STORAGE: 100 readings (DDC mode), 15706 max. readings (SCPI mode).

READING RATE:

To internal buffer	125 readings/second[1]
To IEEE-488 bus	115 readings/second[1,3]
To front panel	17 readings/second[2]
Bus transfer	2500 readings/second[3]

Note: [1] 0.01 PLC, digital filters off, front panel off, temperature + RH off.
[2] 1.00 PLC, digital filters off, temperature + RH off.
[3] Binary transfer mode.

DIGITAL FILTER: Median and averaging.

ENVIRONMENT:

Operating: 0°-50°C; relative humidity 70% non-condensing, up to 35°C.

Storage: -25° to +65°C.

WARM-UP: 1 hour to rated accuracy (see manual for recommended procedure).

POWER: 105–125V or 210–250V (external switch selected), 90–110V (internal switch selected), 50–60Hz, 50VA.

PHYSICAL:

Case Dimensions: 90mm high × 214mm wide × 369mm deep (3½ in. × 8½ in. × 14½ in.).

Working Dimensions: From front of case to rear including power cord and IEEE-488 connector: 15.5 inches.

Net Weight: <4.6 kg (<10.1 lbs.).

Shipping Weight: <9.5 kg (<21 lbs.).

ACCESSORIES SUPPLIED:

Model 237-ALG-2 Low Noise Triax Cable, 3-slot Triax to Alligator clips 2m (6.6 ft.).

Model 8606 High Performance Modular Probe Kit.

Model 8607 Safety High Voltage Dual Test Leads.

Model 6517-TP Thermocouple Input Lead.

CS-459 Interlock Connector.

Specifications subject to change without notice.

B

Calibration Messages

B.1 Introduction

This appendix lists error query commands, errors that may occur during calibration, and summarizes the :CAL:PROT:DATA? query response messages.

B.2 Error summary

Table B-1 lists Model 6517 calibration error queries, and Table B-2 summarizes Model 6517 calibration errors. The errors listed in Table B-1 may be requested with the :SYSTem:ERRor? query, while responses to error queries listed in Table B-2 are shown in Figure B-1 through Figure B-8.

Table B-1
Calibration error responses

Error number	Message	Description
Volts Function Errors		
+350	"2V offset out of spec"	2V range offset error
+351	"2V pgain out of spec"	2V range positive slope error
+352	"2V ngain out of spec"	2V range negative slope error
+353	"20V offset out of spec"	20V range offset error
+354	"20V pgain out of spec"	20V range positive slope error
+355	"20V ngain out of spec"	20V range negative slope error
+356	"200V offset out of spec"	200V range offset error
+357	"200V pgain out of spec"	200V range positive slope error
+358	"200V ngain out of spec"	200V range negative slope error
Current Function Errors		
+359	"20pA offset out of spec"	20pA range offset error
+360	"20pA pgain out of spec"	20pA range positive slope error
+361	"20pA ngain out of spec"	20pA range negative slope error
+362	"200pA offset out of spec"	200pA range offset error
+363	"200pA pgain out of spec"	200pA range positive slope error
+364	"200pA ngain out of spec"	200pA range negative slope error
+365	"2nA offset out of spec"	2nA range offset error
+366	"2nA pgain out of spec"	2nA range positive slope error
+367	"2nA ngain out of spec"	2nA range negative slope error
+368	"20nA offset out of spec"	20nA range offset error
+369	"20nA pgain out of spec"	20nA positive slope error
+370	"20nA ngain out of spec"	20nA negative slope error
+371	"200nA offset out of spec"	200nA range offset error
+372	"200nA pgain out of spec"	200nA range positive slope error
+373	"200nA ngain out of spec"	200nA range negative slope error
+374	"2uA offset out of spec"	2µA range offset error
+375	"2uA pgain out of spec"	2µA range positive slope error
+376	"2uA ngain out of spec"	2µA range negative slope error
+377	"20uA offset out of spec"	20µA range offset error
+378	"20uA pgain out of spec"	20µA range positive slope error
+379	"20uA ngain out of spec"	20µA range negative slope error
+380	"200uA offset out of spec"	200µA range offset error
+381	"200uA pgain out of spec"	200µA range positive slope error
+382	"200uA ngain out of spec"	200µA range negative slope error
+383	"2mA offset out of spec"	2mA range offset error
+384	"2mA pgain out of spec"	2mA range positive slope error
+385	"2mA ngain out of spec"	2mA range negative slope error
+386	"20mA offset out of spec"	20mA range offset error
+387	"20mA pgain out of spec"	20mA range positive slope error
+388	"20mA ngain out of spec"	20mA range negative slope error
Charge Function Errors		
+389	"2nC pgain out of spec"	2nC range positive slope error
+390	"2nC ngain out of spec"	2nC range negative slope error
+391	"20nC pgain out of spec"	20nC range positive slope error
+392	"20nC ngain out of spec"	20nC range negative slope error
+393	"200nC pgain out of spec"	200nC range positive slope error

Table B-1
Calibration error responses (cont.)

Error number	Message	Description
Charge Function Errors (cont.)		
+394	"200nC ngain out of spec"	200nC range negative slope error
+395	"2uC pgain out of spec"	2μC range positive slope error
+396	"2uC ngain out of spec"	2μC range negative slope error
Temperature Function Errors		
+399	"Temperature offset out of spec"	Temperature function offset error
+400	"Temperature gain out of spec"	Temperature function gain error
Humidity Function Errors		
+409	"Hum. 50% offset out of spec"	50% humidity offset error
+410	"Hum. 100% offset out of spec"	100% humidity offset error
+411	"Hum. 50% gain out of spec"	50% humidity gain error
+412	"Hum. 100% gain out of spec"	100% humidity gain error
Offset Calibration Errors		
+413	"Voltage Offset not converging"	Voltage offset calibration error
+414	"Current Offset not converging"	Current offset calibration error
Voltage Source Errors		
+415	"VSRC 100V offset out of spec"	100V range offset error
+416	"VSRC 100V pgain out of spec"	100V range positive slope error
+417	"VSRC 100V ngain out of spec"	100V range negative slope error
+418	"VSRC 1kV offset out of spec"	1000V range offset error
+419	"VSRC 1kV pgain out of spec"	1000V range positive slope error
+420	"VSRC 1kV ngain out of spec"	1000V range negative slope error
Factory Calibration Errors		
+421	"Voltage Offset out of spec"	
+422	"Current Offset out of spec"	
+423	"Zero Check CAL Error"	
Calibration Execution Errors		
+424	"Date of calibration not set"	Calibration date not set error
+425	"Next date of calibration not set"	Calibration due date not set error
+426	"Calibration not initialized"	Calibration not initialized error
+427	"Illegal Calibration Command"	Illegal calibration command error
Power-on Errors		
+513	"Calibration data lost"	Calibration data lost error
+514	"Calibration dates lost"	Calibration dates lost error
+515	"Calibration tolerances lost"	Calibration tolerances lost error
+516	"Calibration tables lost"	Calibration tables lost error
+517	"Voltage Offset lost"	Voltage offset value lost error
+518	"Current Offset lost"	Current offset value lost error
+519	"Installed option id lost"	Option ID lost error
+520	"Option card not supported"	Option card not supported error
+521	"Cal Card Data Error"	Calibration unit data error

Note: Bus response to query includes error number, comma, and error message surrounded by double quotes.

Table B-2
Calibration error query commands

Error number	Message	Figure
:CALibration:		
UNPRotected:		
EERR?	Request cal execution error status	B-1
VERR?	Request voltage function cal errors	B-2
AERR?	Request current function cal errors	B-3
CERR?	Request charge function cal errors	B-4
TERR?	Request temperature function cal errors	B-5
HERR?	Request humidity function cal errors	B-6
SERR?	Request voltage source cal errors	B-7
FERR?	Request factory cal errors	B-8

Table B-3
Calibration constants returned by :CAL:PROT:DATA? query

Order	Calibration constant description
1	Volts function 2V range zero offset
2	Volts function 2V range positive slope
3	Volts function 2V range negative slope
4	Volts function 20V range zero offset
5	Volts function 20V range positive slope
6	Volts function 20V range negative slope
7	Volts function 200V range zero offset
8	Volts function 200V range positive slope
9	Volts function 200V range negative slope
10	Amps function 20pA range zero offset
11	Amps function 20pA range positive slope
12	Amps function 20pA range negative slope
13	Amps function 200pA range zero offset
14	Amps function 200pA range positive slope
15	Amps function 200pA range negative slope
16	Amps function 2nA range zero offset
17	Amps function 2nA range positive slope
18	Amps function 2nA range negative slope
19	Amps function 20nA range zero offset
20	Amps function 20nA range positive slope
21	Amps function 20nA range negative slope
22	Amps function 200nA range zero offset
23	Amps function 200nA range positive slope
24	Amps function 200nA range negative slope
25	Amps function 2µA range zero offset
26	Amps function 2µA range positive slope
27	Amps function 2µA range negative slope
28	Amps function 20µA range zero offset
29	Amps function 20µA range positive slope
30	Amps function 20µA range negative slope
31	Amps function 200µA range zero offset
32	Amps function 200µA range positive slope
33	Amps function 200µA range negative slope
34	Amps function 2mA range zero offset
35	Amps function 2mA range positive slope
36	Amps function 2mA range negative slope
37	Amps function 20mA range zero offset
38	Amps function 20mA range positive slope
39	Amps function 20mA range negative slope
40	Coulombs function 2nC range zero check A
41	Coulombs function 2nC range zero check B
42	Coulombs function 2nC range positive slope
43	Coulombs function 2nC range negative slope
44	Coulombs function 20nC range zero check A
45	Coulombs function 20nC range zero check B

Table B-3
Calibration constants returned by :CAL:PROT:DATA? query (cont.)

Order	Calibration constant description
46	Coulombs function 20nC range positive slope
47	Coulombs function 20nC range negative slope
48	Coulombs function 200nC range zero check A
49	Coulombs function 200nC range zero check B
50	Coulombs function 200nC range positive slope
51	Coulombs function 200nC range negative slope
52	Coulombs function 2nC range zero check A
53	Coulombs function 2nC range zero check B
54	Coulombs function 2nC range positive slope
55	Coulombs function 2nC range negative slope
56	Temperature function offset
57	Temperature function slope
58	Internal temperature
59	Humidity function 0V offset
60	Humidity function 0V slope
61	Humidity function 1V offset
62	Humidity function 1V slope
63	Volts function 2V range zero check offset
64	Volts function 20V range zero check offset
65	Volts function 200V range zero check offset
66	Amps function 20pA range zero check offset
67	Amps function 200pA range zero check offset
68	Amps function 2nA range zero check offset
69	Amps function 20nA range zero check offset
70	Amps function 200nA range zero check offset
71	Amps function 2µA range zero check offset
72	Amps function 20µA range zero check offset
73	Amps function 200µA range zero check offset
74	Amps function 2mA range zero check offset
75	Amps function 20mA range zero check offset
76	Coulombs function 2nC range zero check offset
77	Coulombs function 20nC range zero check offset
78	Coulombs function 200nC range zero check offset
79	Coulombs function 2µC range zero check offset
80	Voltage source 100V range zero offset
81	Voltage source 100V range positive slope
82	Voltage source 100V range negative slope
83	Voltage source 1000V range zero offset
84	Voltage source 1000V range positive slope
85	Voltage source 1000V range negative slope

NOTE: Constants are returned as an ASCII string of floating-point numbers separated by commas. Constants are sent in the order shown, and entire string is terminated by a newline (<LF> + EOI).

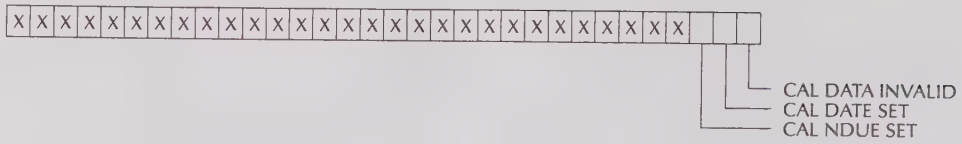

Figure B-1
EERR? query response (calibration execution errors)

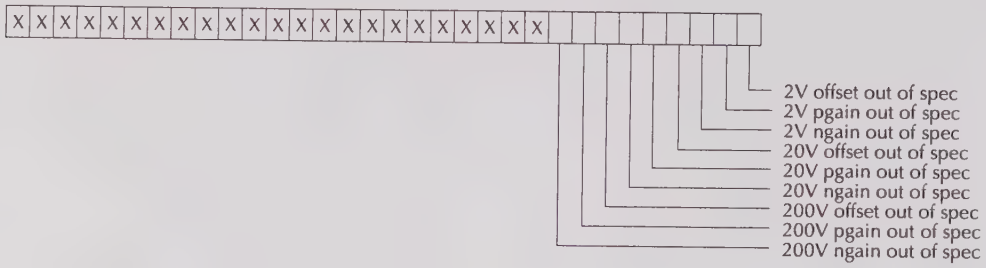
2V offset out of spec
2V pgain out of spec
2V ngain out of spec
20V offset out of spec
20V pgain out of spec
20V ngain out of spec
200V offset out of spec
200V pgain out of spec
200V ngain out of spec

Figure B-2
VERR? query response (voltage function cal errors)

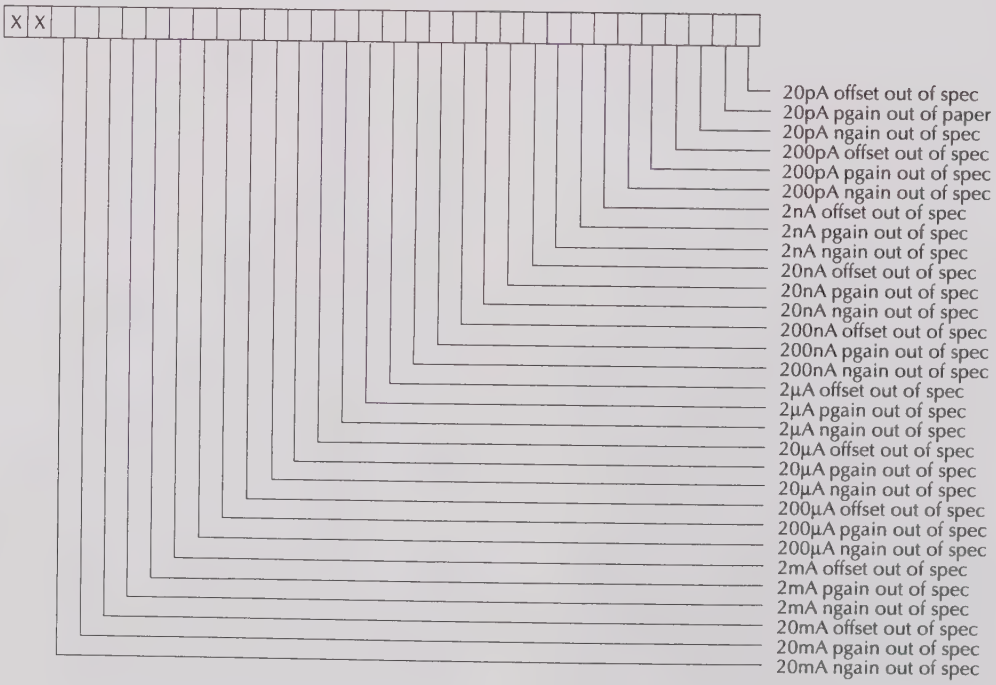
20pA offset out of spec
20pA pgain out of paper
20pA ngain out of spec
200pA offset out of spec
200pA pgain out of spec
200pA ngain out of spec
2nA offset out of spec
2nA pgain out of spec
2nA ngain out of spec
20nA offset out of spec
20nA pgain out of spec
20nA ngain out of spec
200nA offset out of spec
200nA pgain out of spec
200nA ngain out of spec
2µA offset out of spec
2µA pgain out of spec
2µA ngain out of spec
20µA offset out of spec
20µA pgain out of spec
20µA ngain out of spec
200µA offset out of spec
200µA pgain out of spec
200µA ngain out of spec
2mA offset out of spec
2mA pgain out of spec
2mA ngain out of spec
20mA offset out of spec
20mA pgain out of spec
20mA ngain out of spec

Figure B-3
IERR? query response (current function cal errors)

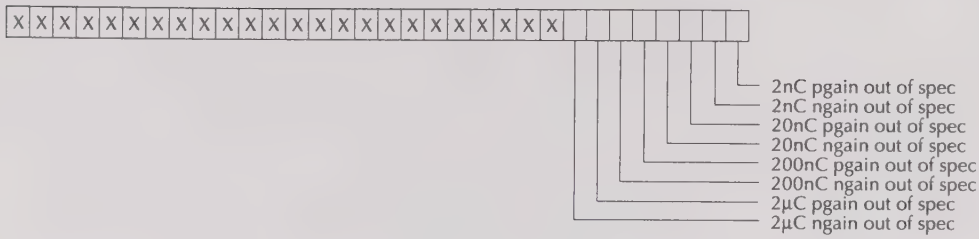
2nC pgain out of spec
2nC ngain out of spec
20nC pgain out of spec
20nC ngain out of spec
200nC pgain out of spec
200nC ngain out of spec
2µC pgain out of spec
2µC ngain out of spec

Figure B-4
CERR? query response (coulombs function cal errors)

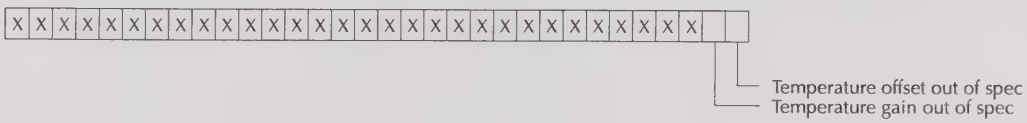

Figure B-5
TERR? query response (temperature function cal errors)

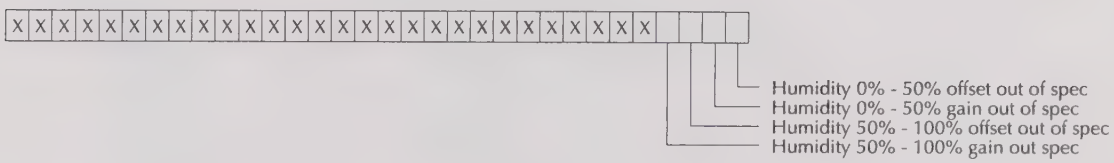
Humidity 0% - 50% offset out of spec
Humidity 0% - 50% gain out of spec
Humidity 50% - 100% offset out of spec
Humidity 50% - 100% gain out spec

Figure B-6
HERR? query response (humidity function cal errors)

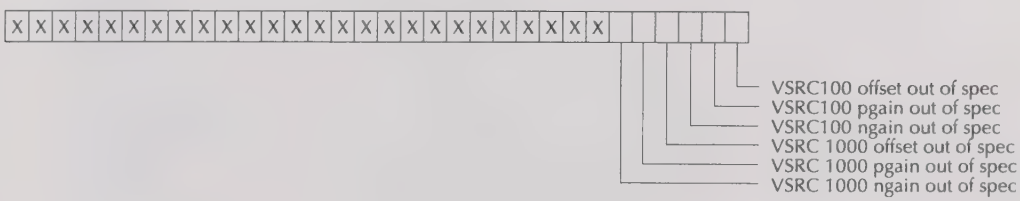
VSRC100 offset out of spec
VSRC100 pgain out of spec
VSRC100 ngain out of spec
VSRC 1000 offset out of spec
VSRC 1000 pgain out of spec
VSRC 1000 ngain out of spec

Figure B-7
SERR? query response (voltage source cal errors)

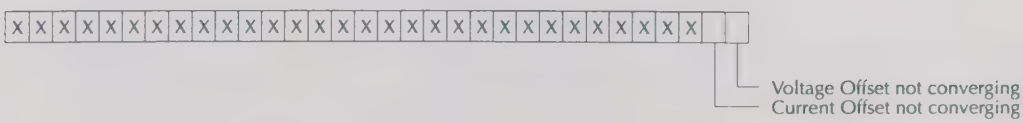

Figure B-8
FERR? query response (factor cal errors)

C

Calibration Command Summary

Table C-1
Calibration commands

Command	Description
CALibration:	Calibration subsystem
PROTected:	Commands protected by CAL switch
INITiate	Required before performing ANY cal steps
VZERO2	2V range zero step
V2 <Nrf>	+2V step
VN2 <Nrf>	-2V step
VZERO20	20V range zero step
V20 <Nrf>	+20V step
VN20 <Nrf>	-20V step
VZERO200	200V range zero step
V200 <Nrf>	+200V step
VN200 <Nrf>	-200V step
AZERO20P	20pA range zero step
A20P <Nrf>	+20pA step
A20PCARD <Nrf>	+20pA step (using cal standard)
AN20P <Nrf>	-20pA step
AN20PCARD <Nrf>	-20pA step (using cal standard)
AZERO200P	200pA range zero step
A200P <Nrf>	+200pA step
A200PCARD <Nrf>	+200pA step (using cal standard)
AN200P <Nrf>	-200pA step
AN200PCARD <Nrf>	-200pA step (using cal standard)
AZERO2N	2nA range zero step
A2N <Nrf>	+2nA step
A2NCARD <Nrf>	+2nA step (using cal standard)
AN2N <Nrf>	-2nA step
AN2NCARD <Nrf>	-2nA step (using cal standard)
AZERO20N	20nA range zero step
A20N <Nrf>	+20nA step
A20NCARD <Nrf>	+20nA step (using cal standard)

Table C-1
Calibration commands

Command	Description
CALibration:	
PROTected:	
AN20N <Nrf>	-20nA step
AN20NCARD <Nrf>	-20nA step (using cal standard)
AZERO200N	200nA range zero step
A200N <Nrf>	+200nA step
A200NCARD <Nrf>	+200nA step (using cal standard)
AN200N <Nrf>	-200nA step
AN200NCARD <Nrf>	-200nA step (using cal standard)
AZERO2U	2µA range zero step
A2U <Nrf>	+2µA step
A2UCARD <Nrf>	+2µA step (using cal standard)
AN2U <Nrf>	-2µA step
AN2UCARD <Nrf>	-2µA step (using cal standard)
AZERO20U	20µA range zero step
A20U <Nrf>	+20µA step
AN20U <Nrf>	-20µA step
AZERO200U	200µA range zero step
A200U <Nrf>	+200µA step
AN200U <Nrf>	-200µA step
AZERO2M	2mA range zero step
A2M <Nrf>	+2mA step
AN2M <Nrf>	-2mA step
AZERO20M	2mA range zero step
A20M <Nrf>	+20mA step
AN20M <Nrf>	-20mA step
CZEROA2N	2nC range zero check part A
C2N <Nrf>	+2nC step
C2NCARD <Nrf>	+2nC step (using cal standard)
CZEROB2N	2nC range zero check part B
CN2N <Nrf>	-2nC step
CN2NCARD <Nrf>	-2nC step (using cal standard)
CZEROA20N	20nC range zero check part A
C20N <Nrf>	+20nC step
C20NCARD <Nrf>	+20nC step (using cal standard)
CZEROB20N	20nC range zero check part B
CN20N <Nrf>	-20nC step
CN20NCARD <Nrf>	-20nC step (using cal standard)
CZEROA200N	200nC range zero check part A
C200N <Nrf>	+200nC step
C200NCARD <Nrf>	+200nC step (using cal standard)
CZEROB200N	200nC range zero check part B
CN200N <Nrf>	-200nC step
CN200NCARD <Nrf>	-200nC step (using cal standard)
CZEROA2U	2µC range zero check part A
C2U <Nrf>	+2µC step
C2UCARD <Nrf>	+2µC step (using cal standard)
CZEROB2U	2µC range zero check part B
CN2U <Nrf>	-2µC step
CN2UCARD <Nrf>	-2µC step (using cal standard)

Table C-1
Calibration commands

Command	Description
CALibration:	
PROTected:	
TZERO	0mV (0°C) temperature step
T50	+50mV (1232°C) temperature step
T1232	+50mV (1232°C) temperature step (alternate)
VSETZ100	Set voltage source to 0V for next command
VSRCZ100 <Nrf>	Voltage source 100V range 0V cal
VSETZ1000	Set voltage source to 0V for next command
VSRCZ1000 <Nrf>	Voltage source 1000V range 0V cal
VSET40	Set voltage source to +40V
VSRC40 <Nrf>	Voltage source +40 V cal
VSET100	Set voltage source to +100V
VSRC100 <Nrf>	Voltage source +100V cal
VSETN100	Set voltage source to -100V
VSRCN100 <Nrf>	Voltage source -100V cal
VSET400	Set voltage source to +400V
VSRC400 <Nrf>	Voltage source +400V cal
VSET1000	Set voltage source to +1000V
VSRC1000 <Nrf>	Voltage source +1000 V cal
VSETN1000	Set voltage source to -1000 V
VSRCN1000 <Nrf>	Voltage source -1000 V cal
HUMZERO	Humidity input 0 V step
HUM05	Humidity input 0.5 V step
HUM1	Humidity input 1.0 V step
LOCK	Re-locks the calibration paths. (A new CAL switch press and CAL:PROT:INIT command are required before any cal commands can be performed again.)
SAVE	Saves the cal constants in NVRAM
DATE <yyyy, mm, dd>	Calibration date yyyy = year (1994-2093), mm = month (1-12), dd =date (1-31)
DATE?	Request calibration date
NDUE <yyyy, mm, dd>	Calibration due date
NDUE?	Request calibration due date
SWITch?	Request CAL switch state (0 = unlocked, 1 = locked)
CALTEMP	Acquire the calibration temperature.
UNPRotected:	These commands not protected by CAL switch
VOFFset	Perform offset voltage calibration
IOFFset	Perform bias current calibration
EERR?	Request cal execution error status
VERR?	Request voltage function cal errors
AERR?	Request amps function cal errors
CERR?	Request coulombs function cal errors
TERR?	Request temperature function cal errors
FERR?	Request factory calibration errors
OPTion?	Request cal option presence status

NOTE: Upper-case letters indicate short form of each command. For example, instead of sending ":CALibration:PROTected:INITiate", you can send":CAL:PROT:INIT".

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Service Form

Model No. _____ **Serial No.** _____ **Date** _____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

- ❑ Intermittent
- ❑ IEEE failure
- ❑ Front panel operational
- ❑ Analog output follows display
- ❑ Obvious problem on power-up
- ❑ All ranges or functions are bad
- ❑ Particular range or function bad; specify _____
- ❑ Batteries and fuses are OK
- ❑ Checked all cables

Display or output (check one)

- ❑ Drifts
- ❑ Unstable
- ❑ Overload
- ❑ Unable to zero
- ❑ Will not read applied input

- ❑ Calibration only
- ❑ Data required
- ❑ Certificate of calibration required

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

_____

_____

What power line voltage is used? _____ Ambient temperature? _____ °F

Relative humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

KEITHLEY

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Cleveland, Ohio 44139

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